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MAY 2006

Brains Conquer Beauty

Scientists break code to create perfect gemstones with even more fire and brilliance than mined diamonds.

There is little doubt that a natural mined diamond of top quality is one of the world's most magnificent gems. It is much coveted for its exquisite beauty, but the simple truth is that diamonds are just compressed crystallized carbon. The laboratories at Diamond*Aura* were created with one mission in mind: Design classic jewelry with scientifically perfect gemstones at a cost that lets everyone experience a stone with more fire and brilliance than a mined diamond.

Perfection from the laboratory. We named our gemstones Diamond*Aura*, because simply said, "they dazzle just like natural diamonds but without the outrageous cost." Our Diamond*Auras* are an absolute marvel of modern gemological science. We insisted that our scientists reproduce the look of a natural mined diamond in the laboratory, and would not accept any result other than perfection. We will not bore you with the incredible details of the scientific process, but will only say that it involves the use of natural occurring minerals heated to an incredibly high temperature over 5000°F. This can only be accomplished inside some very modern and very expensive laboratory equipment. After several additional steps, our scientists have finally created a gemstone that looks even better than the vast majority of mined diamonds. Frankly, each time we see one, we have difficulty believing the result ourselves. Noted jewelry expert Steven Rozensky said, "The color and clarity of Diamond*Aura* rivals that of a flawless D colored diamond". Of course, flawless diamonds sell for in excess of $50,000 a carat, so they are priced out of reach. Only experienced diamond appraisers utilizing the proper instruments are able to make the distinction between a flawless natural diamond and a scientifically perfect Diamond*Aura*.

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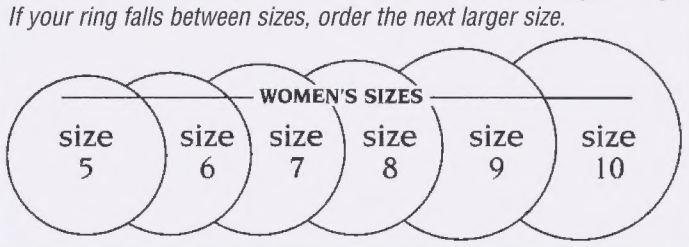
Place one of your own rings on top of one of the circles. Your ring size is the circle that matches the diameter of the inside of your ring. If your ring falls between sizes, order the next larger size.



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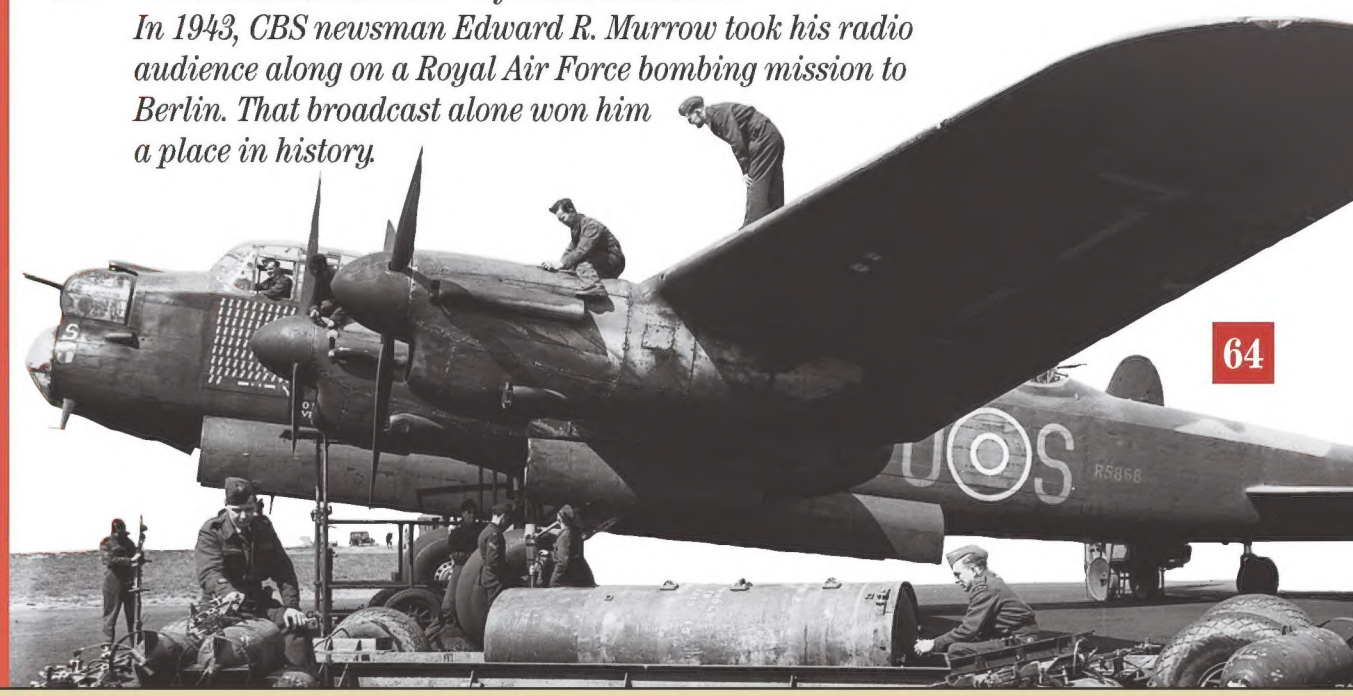

SEE IT ALL AIR&SPACE
2006 AIRSHOW SPECIAL

Cover:
Look ahead—with the imaginative help of artist Paul DiMare—to the year 2018, when the only country ever to land people on the moon begins to send up more.

DEPARTMENTS

Bags of Vintage US Silver Coins Saved From Govt. Melt-Down!

For the first time ever the First Federal Mint is releasing to the public bags of historic U.S. silver coins not seen in circulation for decades. They are priced not by the rarity of the individual coin but by silver weight... in full size Quarter Pound, Half Pound and One Pound bags.

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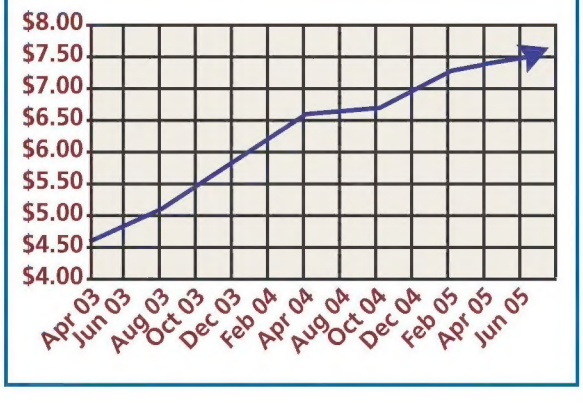
Price of Silver on the Rise



The surviving American silver coins are becoming more sought-after with each passing day.

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No Runway Required

We have grown so accustomed to the sight of the president's helicopter alighting on the White House lawn that it's difficult to imagine a president arriving any other way. But the first presidential helicopter flight took place only after U.S. security planners, wanting to test plans for escape in case of nuclear attack, sent President Dwight D. Eisenhower to a bunker outside the city in his limousine. When Eisenhower arrived, his cabinet members, who had traveled by helicopter, were there to greet him. The result of that test was the 1957 purchase of a Bell H-13J, the first presidential helicopter, which visitors can now see in the Vertical Flight exhibit at the National Air and Space Museum's Steven F. Udvar-Hazy Center. The exhibit features the many weird and wonderful solutions to the problem of operating aircraft away from airport infrastructure and includes the most comprehensive collection of early vertical-takeoff-and-landing and rotary-wing aircraft anywhere.

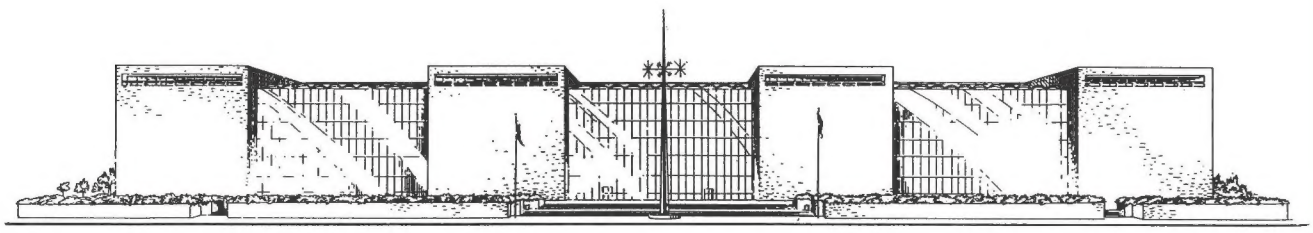
The first successful rotary-wing aircraft was a hybrid: The 1930s autogiro was essentially an airplane with an unpowered (autorotating) lifting rotor. Though it could not hover, it was safe and convinced many that a practical helicopter was possible. The Museum's examples, such as the Autogiro Company of America AC-35 and the Kellett XO-60, were technical successes but commercial failures. Still, autogiro experience paid off with the helicopter. Igor Sikorsky's R-4, the world's first mass-produced helicopter, used 39 inventions patented for the autogiro. On display is the prototype, the XR-4, which sold the U.S. military on the viability of the helicopter.

Sikorsky's achievements in the early 1940s led to predictions of a post-war aviation boom. Scores of companies scrambled to build helicopters, but only a few were successful.

The collection features the most notable examples from this pioneering period: Bell's Model 30 (see In the Museum, p. 14), Piasecki's PV-2, and Hiller's XH-44. All are the first craft made by these industry leaders. Bell built affordable lightweight helicopters beginning with the Model 47B, the first helicopter certified by the Civil Aeronautics Authority. The Museum's 47B holds the record for the longest operational life of any helicopter (1947–2004) and set the world's hovering record (50 hours, 50 seconds). In 1944, at the age of 19, Stanley Hiller Jr. designed, built, and test flew the coaxial XH-44. This machine launched Hiller's innovative company, and the Museum has several of his exotic machines. The XHOE-1 Hornet, powered by ramjets on the rotor tips, is currently on display, and the foldable YROE-1 Rotorcycle and the Flying Platform will soon follow.

Perhaps the most innovative VTOL aircraft to come into our collection is a recent development: the Bell XV-15 Tilt Rotor Research Aircraft. By cruising as efficiently as an airplane, the tilt rotor has enormous advantages over conventional helicopters in speed and in range and is the only class of VTOL transports to go into full-scale production. From autogiro to XV-15, this little-known aspect of aviation history awaits you at the Udvar-Hazy Center.

—J.R. Dailey is the director of the National Air and Space Museum.



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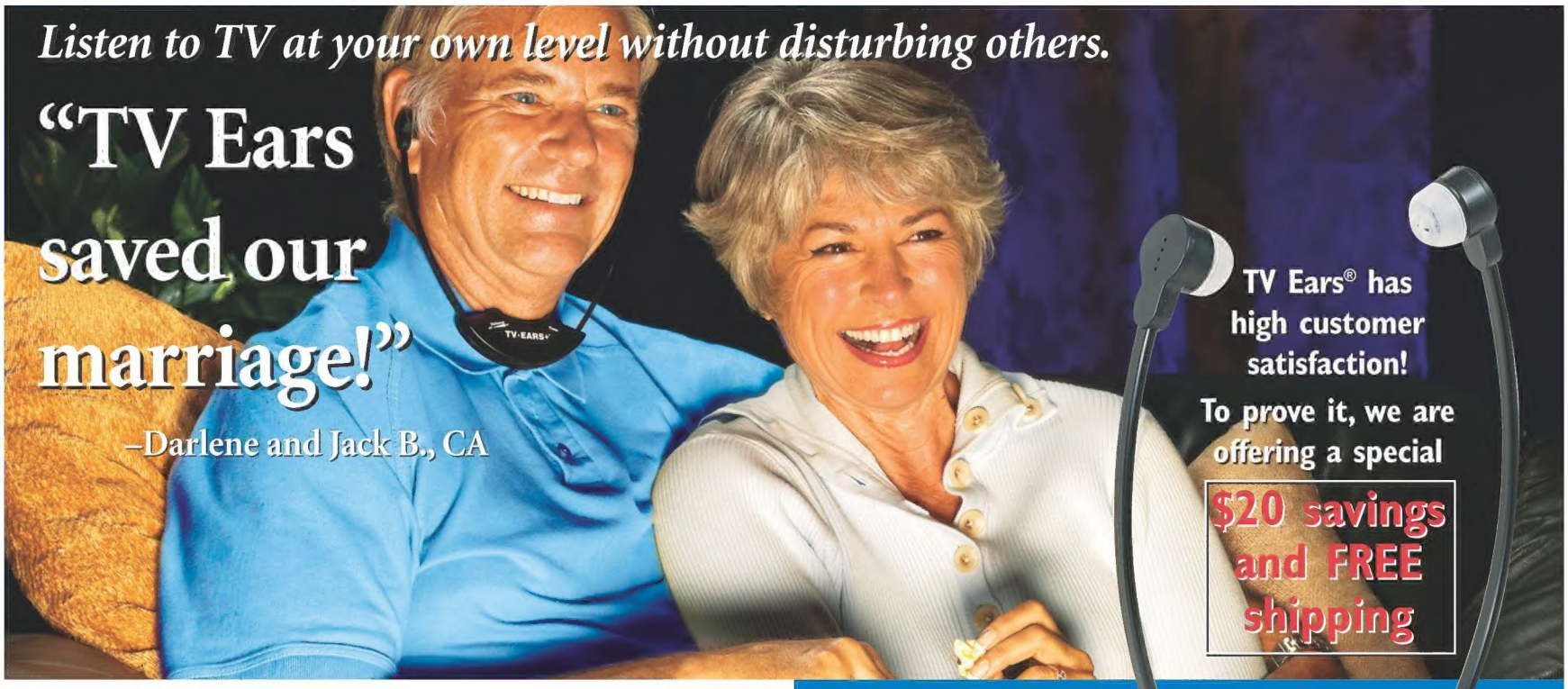

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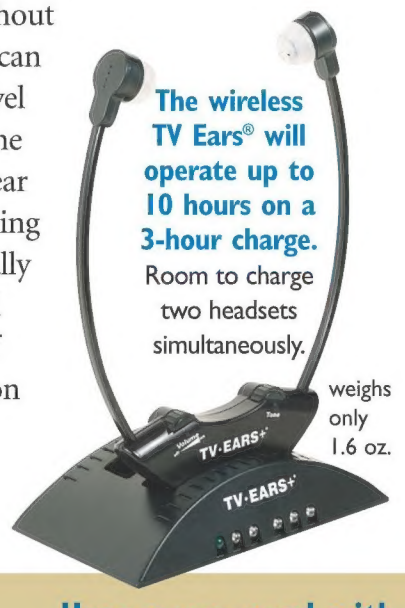

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LETTERS

Hung Up in Knots

One of my Christmas gifts last year was John T. Halliday's book *Flying Through Midnight.* I found it very enjoyable and have recommended it to my flying friends.

I was surprised—more like shocked—to read Bob Hanson's review (Dec. 2005/Jan. 2006). I did not fly the C-123 and am not familiar with airfields in Laos. I am, however, a pilot, and I take particular issue with the reviewer's statement "He also claims to have…hung [the C-123] on its props like a helicopter, at a speed of 50 knots, which any pilot will tell you is impossible."

L.L. Boles
Tiburon, California

Bob Hanson replies: I have flown the C-123, briefly, and many years ago. My recollection is that it was a wallowing hog of an airplane with all the aerodynamic grace of a flying shoe box, and I really admire the guys who flew them in Vietnam.

I still have the Air Force pilot manual for the -123, and when I compute the stall speed for, say, 54,000 pounds gross weight (and that is probably light for a combat configuration), power-on stall, and zero-degree bank, I come up with something around 92 knots. Throw in the jet engines, and maybe you could reduce that to 80-plus. Bob Hoover might be able to pull off something like the 50-knot maneuver, but I doubt he would even care to try.

Venturiana

In "Fire and Ice" (Feb./Mar. 2006), Ralph Wetterhahn wrote about the last flight of a PV-1, tail number 31. Recently there was also a program on PBS about the last flight of number 31. Neither the article nor the program explored why the pilot did not jettison the bombs and thus increase the range of flight and reduce the chance of an explosion on landing. Can Ralph Wetterhahn answer that question?

Gary Grady
San Gabriel, California

Ralph Wetterhahn responds: I've given that question considerable thought in the past. Most likely, the answer is one of the following.

(1) The airplane received battle damage that affected the operation of the bomb bay doors, thus preventing release. These doors had a history of malfunctions, even without battle damage.

(2) The crew members knew they were over part of the Soviet Union and did not want to drop explosives over "friendly" territory.

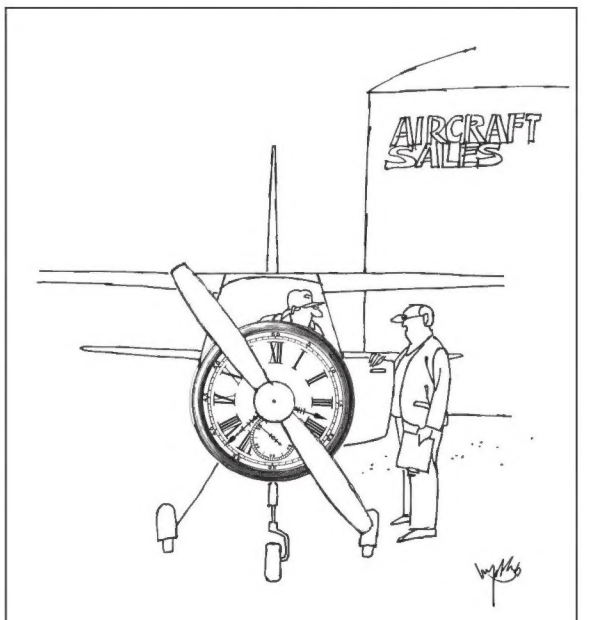
(3) The airplane was attacked, and as the crew evaded the Japanese, they kept the bomb bay doors closed, since opening them to jettison bombs would reduce airspeed. Once clear of the threat, the crew might not have had sufficient time to jettison the bombs if both engines had lost power and the only relatively safe haven was on the side of the volcano that protruded above low fog/clouds.

If I were a betting man, I'd go with the first possibility.

I remember the day I read the article in our local newspaper about the discovery of the PV-1 wreckage in Russia. I was excited because it was the first time I had ever seen anything in print about the PV-1. My father, L. Hoyt Peterson, had flown in the PV-1 and PV-2 in the South Pacific, with Squadron VP-148, and also in stations in the States. I have his flight log, which shows 679 hours of air time, almost all of it in PV-1s and PV-2s.

About three or four years ago I did a Google search on these planes and got only two hits. Recently I did another search and got hundreds of hits. I'm very happy that the PV-1s and PV-2s are getting some recognition. I wish my dad was here to see it, but he passed on four years ago.

Robert A. Peterson
Toms River, New Jersey



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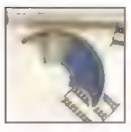
The Van Hauser timepiece turns back the hands of time to the 1920s, an era of unparalled craftsmanship in watch making. This classic wristwatch is now available to those who have a penchant for exquisite timepieces. Collectors have been known to pay several thousands dollars for watches that have details from the classic 1920s era.

No batteries. No winding.

Today it's rare to find a watch that doesn't run on batteries. The Van Hauser's mechanical (automatic) movement uses kinetic energy—which means it winds itself by the normal motion of your hand during the course of the day. The Van Hauser never needs to be wound.



Early timepiece complications

During the 1920s early watch complications began to appear in only the finest timepieces. The Van Hauser reflects this landmark in timekeeping history by incorporating two sub dials—24-hour clock and 60-second dial. In addition, it features a unique day/night phase indicator.

Fascinating Transparent Dial

The Tourbillon (French for "Whirlwind") is one of the most admired and sought after features in time keeping history, invented in 1795 by Abraham Breguet. Unique classic watches from the 1920's have featured this coveted movement. Collectors have been known to pay up to $779,000 for an original. The Van Hauser has the vintage style and appearance of watches from that bygone era. It features a unique porthole on the front of the watch, where you can actually see the intricate movements of the watch as it is working.

1920s craftsmanship meets 2006 technology

The Van Hauser timepiece has been painstakingly crafted and assembled by hand to reproduce the characteristics of the finest watches of that classic era and even has an exceptional 22-jewel movement. Watch movements of superb quality use such a high number of jewels to prevent wear and tear on the gears. Added features you would not have found in a 1920s watch….water resistance construction and luminescent hands…add to the uniqueness of the timepiece.

Van Hauser Timepiece

- Day/Night phase indicator
- Tourbillon (whirlwind) style elegance, front watch visibility
- Kinetic self winding – no batteries or manual winding
- 24-hour clock dial and 60-second dial
- Exceptional 22-jewel movement
- Luminescent hour and minute hands
- Intricately assembled by hand
- Brass case and stainless steel case back
- Water resistant
- Interchangeable black and brown leather wristbands
- Handsome storage case

Wear or display it with your collection

This watch shows the world you have a keen eye for the finer things in life—from the prestigious tourbillon (whirlwind) style, the stainless steel case back to the authentic brass elegant casing plated in genuine micron 18/23 karat gold (black dial face) or genuine micron palladium platinum (antique white dial face). The Van Hauser also comes with an interchangeable brown and black band and a handsome storage case for display or safekeeping. No one will ever guess what you paid for this historic timepiece.

How can we make such an outstanding offer on this classic timepiece?

Retail stores mark watches up accordingly to amortize their expensive shops and boutiques. Through our exclusive arrangement we are able to offer the Van Hauser directly to the consumer without any expensive middleman or stores. Our low overhead enables us to pass this tremendous cost savings to you. And we are so sure that you will love this watch that you get a 30-day, 100% money back guarantee.
NOT AVAILABLE IN STORES.

FOR FASTEST SERVICE CALL

1-800-559-1947

24 hours a day, 7 days a week / we accept checks by phone

Van Hauser Classic Wristwatch **Dept. 9300**
P.O. Box 3012 Wallingford CT 06492
To order by mail please call toll free 1-800-559-1947 for details.

Hard Is Not Strong

"Going Up?" (Feb./Mar. 2006) describes the space elevator concept as relying on a ribbon made of "a material stronger than diamonds." I am not sure what the tensile strength of diamonds is, but I am sure that it is quite low, much lower than that of a carbon fiber material. Yes, diamonds are at the top of the Moh's scale of hardness—but don't try hitting one with a hammer!

Richard W. Reeks
Virginia Beach, Virginia

More From the Hustler Fan Club

In the middle 1960s I was an air traffic controller at O'Hare airport in Chicago. Each morning one or more B-58 Hustlers from the Bunker Hill/Grissom base in Indiana snuck by us and went up around Minneapolis ("Speed Freak," Dec. 2005/Jan. 2006). Then, to complete its mission, it turned around and went supersonic back over Chicago and returned to base. You could almost set your clock by the boom: As I remember, we heard it at about 10:30 a.m. This went on for a number of months and was part of a supersonic-transport study to determine how the public would react to such an event. I think folks in aviation sort of enjoyed it but the general public did not.

It was also fun to watch the target skip across our radar scopes at speeds we normally didn't see.

Martin Coddington
via e-mail

Seeing the long-legged B-58 in the same issue as a picture of Burt Rutan's Proteus carrying a dummy rocket ("Watch This Space") triggers a fun thought. What if a B-58 with the last of the J79 variants had been used as a space launcher? It might have been able to zoom to 45,000 feet at supersonic speed, drop a space launcher while at a 45-degree angle, then continue to pull upward to gain separation before booster ignition. The direction and velocity would certainly give a smart sendoff to the booster.

I agree with Rutan: Someday, we are going to build a very large aircraft in order to reduce the cost and improve the safety of space launches. Can we ever get NASA on board, or should we look to an all-commercial venture?

Ed Hart
via e-mail

Test pilot Joe Cotton's reference to B-58 tire failures brought back memories of when my late father was the manager of tire testing at General Tire. One of his programs was the nose wheel and tire assembly for the B-58. Some time in the late 1950s or early '60s, he took me into a room the size of a basketball court, where a 300-mph dynamometer was devoted to the B-58 program. The dynamometer was capable of simulating the speed and loads of normal and aborted takeoffs and landings. There was an oven that was placed around the tire and wheel assembly to simulate the temperatures of supersonic flight. Surrounding the dynamometer was thick steel plating, and Plexiglas windows were installed for two video cameras. A few feet down from the high roof, chain link fencing served as the room's ceiling.

Most memorable were the remains of a catastrophically failed tire: thin, triangular strips of fabric and rubber attached to the tire's steel beads. The remainder of the tire was scattered all around the room, with several small pieces tangled in the chain link fencing, which had several holes in it at least two feet in diameter. The steel plating wore innumerable skid marks, and one

of the Plexiglas windows was cracked. As my father looked around, he commented: "Thank God we didn't lose the wheel."

Rich Ashley
Akron, Ohio

From the Dead Letter Dept.

It's time to dispense with the idea that the use of the word "dead" in "dead reckoning" evolved from "deduced," as Peter Garrison suggests in "By Stars, Beacons, and Satellites" (Feb./Mar. 2006). According to Merriam-Webster, one definition of "dead" is "exact" or "absolutely uniform," and that usage is found in many familiar engineering and navigation phrases: dead ahead, dead center, dead level, and so on. The word is also used in non-physical terms, especially by the British: dead good, dead on, etc.

Scott Lowrey
North Potomac, Maryland

You Think THAT's Old?

In "Frozen in Time" (Dec 2005/Jan. 2006) Mikey McBryan says, "She's the highest-hour DC-4 ever. Which means she's probably the highest-hour plane in history." Actually, with just 70,000 hours, that aircraft is still relatively young.

The TWA 747 lost off New York in 1996 (registration N93119) was built in 1971 and had at the time of its loss a recorded 93,303 of airframe hours. The 747 operated by MK Airlines (9G-MKI), built 1980 and destroyed on November 27, 2001, had a recorded 80,500 hours. And the Pan Am 747 (739PA) built 1970 and destroyed over Lockerbie, Scotland, on December 21, 1988, had a recorded 72,464 hours.

Arnold Long
Queensland, Australia

Triple Threats

The Moments & Milestones page of the Aug./Sept. 2005 issue says that Dave Riggs "is now the only pilot to hold records for piston-engine aircraft, helicopters, and jet aircraft." The National Aeronautic Association records show that I have set four piston engine aircraft records, three commercial route records, and one rotorcraft record.

Bruce J. Mayes
via e-mail

Corrections

Feb./Mar. 2006 Moments & Milestones (Logbook): BOAC's October 4, 1958 flights were the first Atlantic crossings by commercial airline jet aircraft, not the first Atlantic crossings by any airliner.

Dec. 2005/Jan. 2006 "The Invisible Killers": The Chernobyl nuclear reactor is in Ukraine, not Russia.

"Rotary Club," caption, p. 22: Blue bomb units are inert practice rounds, not live ordnance. (The gray guidance units are, however, functional.)

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Howling Soon at an Airshow Near You

TIM WRIGHT

"We may be biting off too much," says Art Nalls of his effort to put his Harrier on the airshow circuit.

The sound of hooves hammers through the tall security fence surrounding the former Bentwaters Royal Air Force base near Ipswich, England. Art Nalls, a Washington, D.C. real estate developer and former Marine, watches the hounds and red-jacketed huntsmen race past the barbed wire. Behind Nalls, his latest acquisition squats on the concrete: an FA2 Sea Harrier with a low-time Rolls-Royce Pegasus Mk. 104 engine.

Nalls, who has 1,800 hours in the Harrier vertical-takeoff-and-landing jet, plans to be the first civilian to fly one. If all goes well, the retired British fleet air defense fighter, to be based in Delaware, will join the United States' East Coast airshow circuit this year. The sister of the Marines' ground attack AV-8B will join Nalls' other performers—a Czech-made L-39 Albatros jet trainer and a World War II Russian Yak-3 fighter—at upcoming airshows.

As a Marine officer, Nalls graduated from the Air Force test pilot school and became an AV-8A and -8B test pilot, flying at Edwards Air Force Base in California and Patuxent Naval Air Station in Maryland. As part of the test program at these bases, he routinely shut down the single engine to determine if certain modifications prevented inflight engine restarts.

Published reports state the Harrier costs taxpayers about $7,000 per flight hour. Nalls admits he has no idea what his operational costs will be, but he's sure they will be much lower than the military's. "Now that I'll be paying for the tires and the brakes, I'll be a little more gentle with it. Plus, I didn't have to pay $24 million"—about the original price—to acquire it. He bought it through an aircraft broker working with the British Ministry of Defence at what he says was the cost of a World War II fighter—around $1.5 million. "If it flies, I got a good deal," he says. "If it doesn't, I've got an expensive paperweight."

Nalls says there's no shortage of Harrier mechanics in the civilian realm. Because the Harrier is still operational in several countries, Nalls, who also served as a squadron maintenance officer, doesn't expect trouble in obtaining parts either. "The only hangup was the ejection seat," he says. The aircraft was purchased without one. Nalls says the Martin Baker company quoted him over $200,000 for an original-equipment seat, perhaps because the company was fearful of the potential liability. He ended up with a Stencel seat, identical to the one used in the AV-8B.

As for the Harrier's reputation as a pilot killer, Nalls says it's gotten a bad rap. "It was the types of missions it was designed to do," he says. "Low-altitude navigation, bombing, carrier operations—all carry within them a certain degree of risk in and of themselves." He is convinced the Harrier can fully demonstrate its crowd-pleasing vertical-/short-takeoff-and-landing capabilities without being pushed to its limits. At 120 decibels at 50 feet, equal to the din of a rock concert, it's the favorite of earplug vendors at airshows.

—Tim Wright

UPDATE

It's Getting Crowded Up Here

Space Adventures, the company that has sent three millionaires to the International Space Station, has announced that it has jumped on the suborbital-passenger-spaceship bandwagon ("Go Ballistic," Feb./Mar. 2006). The company has contracted with Russia's Federal Space Agency to build a fleet of five-passenger Explorer spacecraft that will be launched from a carrier aircraft. Funding has been promised by Prodea, an investment firm in Texas backed by the Ansari family, which provided much of the $10 million X-Prize purse that was awarded to Burt Rutan's SpaceShipOne effort. Explorers will be sold to operators who will arrange flights from spaceports that Space Adventures will develop in Singapore and the United Arab Emirates.

HEADS UP

16th Annual Pacific Coast Dream Machines Show

Sunday, April 30, 10 a.m.–4 p.m.
Half Moon Bay Airport, California
Highway 1; 20 miles south of San Francisco, 5 miles north of Highway 92
Phone (650) 726-2328
www.miramarevents.com
Tickets ($15 adults, $5 ages 5–14) are available only at the gate.

A showcase of 2,000 mechanical wonders—autos, aircraft, motorcycles, tanks, fire engines, tractors, steamrollers—Dream Machines celebrates 100 years of mechanical ingenuity, power, and style. Bentleys, Packards, Porsches, Rolls-Royces, Thunderbirds, Jaguars, Triumphs, Model Ts, and Mustangs mingle with Grumman Wildcats, TBM Avengers, and Albatroses; North American B-25s and P-51s; Russian Yaks and German Messerschmitts; and British Hawker Sea Furies. Take a ride in a Stearman or Waco biplane, a helicopter, or a Beechcraft warbird for $30 to $75.

PACIFIC COAST DREAM MACHINES

Planes, trains, and automobiles: A Messerschmitt Bf 109 is just one of the showoffs at the Dream Machines show.

A Runway for Runaways

On January 22, 2005, pilots of a Polar Air 747 landing at New York's Kennedy International Airport lost brake function. The jumbo jet overran runway 4R and was approaching a tidal waterway when the malfunction miraculously resolved itself. "They told us, 'All of a sudden our brakes grabbed,' " recalls Peter Mahal, president of ESCO Corporation's engineered-material arresting system division. "Of course, there was snow on the ground so they couldn't see that it really wasn't their brakes grabbing them." What grabbed them was an arrestor bed, which is destined to become a common sight at U.S. airports. "This is a large investment for the [Federal Aviation Administration]," says Ryan King, the arresting system's project lead at the agency's William J. Hughes Technical Center in New Jersey.

Polar's nearly un-dinged 747 returned to service days later. Twenty years of research involving the FAA, the Port Authority of New York and New Jersey, the University of Dayton, and ESCO had paid off.

An average of abut 10 commercial overruns occur annually in the United States. Last December, a Southwest Airlines 737 exceeded a runway at Chicago's Midway Airport and crossed a street, killing a youngster in a car. A week before, Congress had mandated 1,000-foot safety areas at the ends of all commercial runways by 2015. At 300 cramped airports, the safety area would more likely incorporate a Wal-Mart parking lot than vacant land. Where obtaining such real estate is impractical or environmentally unacceptable ("You can't move a wetlands," King notes), the FAA will accept ESCO's arresting system instead.

COURTESY PORT AUTHORITY OF N.Y. AND N.J.

In May 2003, an errant Gemini Air Cargo MD-11 carved up a swath of a Kennedy Airport runway.

Cables and nets have snagged military aircraft for years, but Ryan King says ESCO invented something different: "a completely passive system that didn't have to be triggered." Beds of phenolic plastic stopped test aircraft, but the plastic proved too springy. "It tended to return energy to the aircraft," Peter Mahal says, and reduced the deceleration performance. In 1994, Mahal's company began experimenting with cellular concrete, an air-injected material that when wet resembles shaving cream. ESCO formulated the precise density and strength to fulfill the FAA's mathematical model. After test runs of a Boeing 727B into cellular concrete confirmed the stopping distances that had been predicted by the math, a prototype was installed at JFK in 1996.

A typical 400-foot system ramps to a height of 30 inches. Subjected to the mass and velocity of a speeding aircraft, the rigid cellular concrete disintegrates into granules, applying increasing drag as the aircraft bogs deeper into the mush. An airport's fleet mix determines the tweaking of variables like bed depth and incline. "With big planes, we'll want to ramp up faster to get them into the deepest part of the bed as quick as possible," Mahal says. The physics stipulate that a fully loaded airliner traveling at 80 mph will stop in less than 300 feet.

The first catch was scored at JFK in 1999: an American Eagle SAAB 340 decelerated from 130 mph to zero in 248 feet. With the system now installed at just 14 airports, what the FAA calls "encounters" have occurred only three times in eight years. But postmortems of 37 unarrested runoffs reveal that 33 would have been stopped had the arresting system been in place.

The 1.2-million-pound Airbus A380 will soon land at selected runways—and hopefully stop before reaching the end. But researchers aren't counting on it. "That's what we're looking at now," Mahal says, describing plans for a new-generation composite bed to arrest everything from the very light jet class to a Boeing 747 Advance.

Nevertheless, an engineered material arresting system encounter is not the end-all for every overrun. "A Piper Cub," Mahal observes, "will probably just ride right over the top of it."

—Stephen Joiner

Now, *This* Is Global Warming

Some five billion years from now, the sun will enter its death throes, taking the inner solar system with it. Its transition from a benevolent, life-giving star to a destructive red giant will spare nothing. As it runs out of nuclear fuel, the star will expand, consume Mercury and Venus, and boil all water from Earth's surface before it sheds its mass and becomes a white dwarf.

This is a disconcerting scenario, even if it is five billion years away, at least to a handful of scientists who have studied ways to avoid it. Their various plans have one thing in common: re-engineering the sun so that the process of fusion at its core, which converts hydrogen into helium, thereby releasing energy, will continue for a longer time than is now predicted. Martin Beech, an astronomy professor at the University of Regina in Canada, has calculated that tweaking the star could make it last ten times longer.

"It almost sounds silly to worry about what will happen in billions of years, when we can't tell what will happen next year," says Beech. "But to envision what is potentially possible without the restraints of what is practical is a fun thing to do." Beech spends most of his time studying ways to better analyze Martian rocks but has published occasionally about the sun since 1989.

It's an axiom in astrophysics that the bigger the star, the faster it burns. Beech used computer models of stars to determine that if enough of the sun's mass were removed, it would skip the red giant phase and live out its longer old age as a helium-rich star.

There are several theoretical ways to reduce the sun's mass. One was suggested in the mid-1980s by David R. Criswell, now the director of the University of Houston's Institute for Space Systems Operations. Criswell, an advocate of building solar power plants on the moon, came up with the plan while investigating the settlement and industrialization of the solar system. "I started thinking 'What is the solar system's ultimate resource?' Of course it's the sun," Criswell says. One of his ideas was to steal some of the matter from the sun for use in fusion reactors or in other industrial processes.

A plan of Criswell's for mining the sun involves placing a series of particle accelerators in hardened space stations in orbit around the sun's equator. The accelerators would exchange two beams of oppositely charged ions with their neighbors on each side, forming a circuit around the star that would generate a powerful magnetic field. "The artificial magnetic field provides openings over the north and south poles of the sun through which plasma can escape," Criswell wrote in a 1985 paper.

But to escape the sun, the particles must be moving very fast. "The gas coming out of the poles would rise no higher than solar winds do now," Criswell says. "You need to put more energy into the sun's upper atmosphere over the poles." This could be accomplished by using microwave, laser, or particle beams, according to Criswell, to heat small regions of the star's atmosphere.The coordinated effort would eject plasma in twin jets from the sun's poles.

The sun is 94 percent hydrogen, but only the hydrogen at its core, where the temperatures and pressures are high enough for fusion to occur, is converted to helium. It is estimated that by the time the sun enters the red giant phase, only 12 percent of the hydrogen in today's sun will be converted to helium. When Beech fed different parameters of size and chemical processes into computer models, he found that increasing the amount of hydrogen available for fusion in a smaller sun would cause the star to heat and become much brighter, possibly destroying life on Earth.

"Once the sun's temperature has increased to something like 3.5 times its present value," Beech says, "the temperature at the Earth's surface will have reached the boiling point of water."

Because the luminosity of a star is directly related to its mass—the smaller the mass, the lower the luminosity—solar engineers must balance the rate of mass loss to compensate perfectly for the rise in luminosity as the star becomes increasingly helium-rich.

The alternative—moving Earth away from the sun—is even more wildly impractical. "But when one is thinking this big," says Beech, "who really knows what is best or easiest?"

—Joe Pappalardo

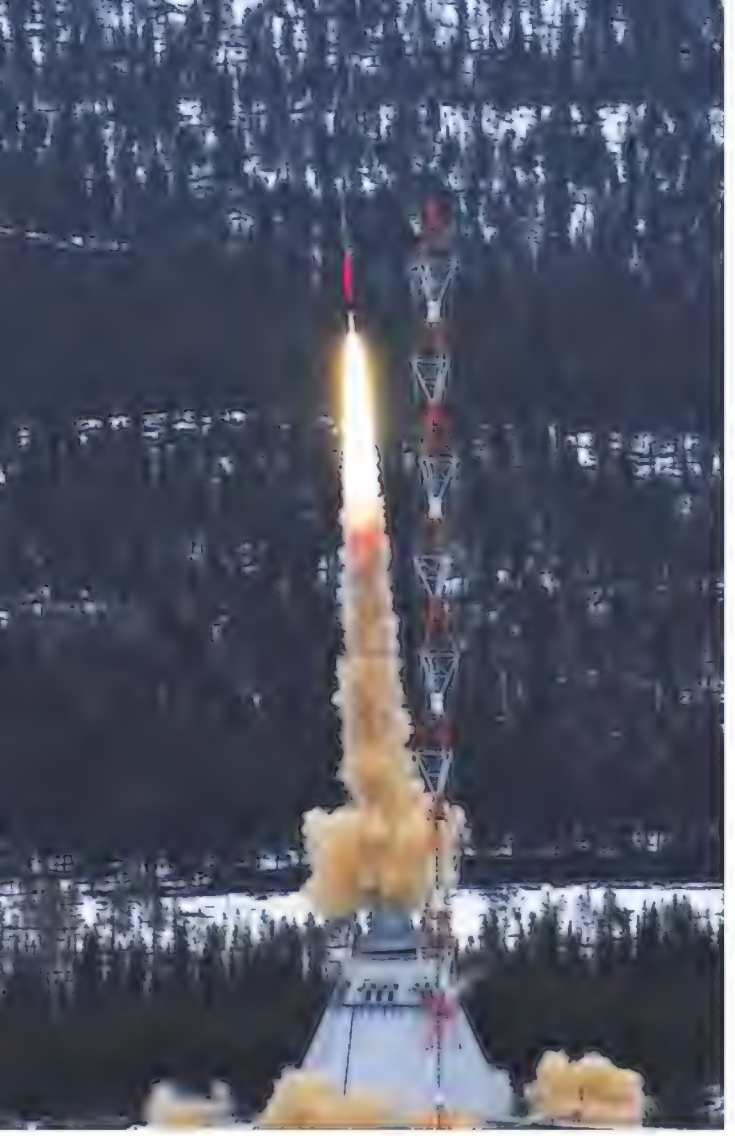
HEADS UP

22nd Annual International Symposium of Air Racing History: Gathering of Air Racing Legends

May 5–7
Holiday Inn—Airport
Brook Park (suburb), Cleveland, Ohio
www.airrace.com
Society of Air Racing Historians, 168 Marian Lane, Berea, OH, 44017

The Society of Air Racing Historians commemorates the 60th anniversary of the post-World War II National Air Races, held in Cleveland from 1946 to 1949, with a reunion of legendary air race pilots. "This will be a celebration of the biggest event in Cleveland's history," says society president Don Berliner. "A dozen or more men and women who thrilled hundreds of thousands of spectators return to the site of their glory days." The 1946 National Air Races kicked off post-war air racing, when surplus military fighters dominated the cross-country Bendix and closed-course Thompson Trophy races. You need not be a society member to attend, but there is an admission fee for the symposium.

SOCIETY OF AIR RACING HISTORIANS VIA GRANTHAM



AP PHOTO / PAUL WHITFIELD

The Skylark's final launch carried five experiments that required microgravity.

Lament for a Skylark

Last May, a Skylark sounding rocket leaped off a launch pad near Kiruna, Sweden, on its 441st launch, ending with a bang the 50-year run of Great Britain's most launched space vehicle. Sounding Rocket Services Ltd., the operators of the Skylark for the last seven years, have been trying to drum up interest in establishing a permanent Skylark exhibition. They've tried the British National Space Centre and the aerospace companies whose antecedents produced the Skylark but to no avail. Says Hugh Whitfield, managing director of SRS, "There is no other project that can hang [its] hat on a 50-year space program, but there is just no interest in a memorial—albeit all involved in British Space activities today, including the [British National Space Centre], owe their existence to the Skylark."

The Skylark grew out of an early 1950s requirement for an inexpensive rocket with which to carry out very-high-altitude research and, critically for Britain's Intermediate Range Ballistic Missile program, reentry research. The Royal Aeronautical Establishment began design work in 1955, with the first launch in 1957, the International Geophysical Year.

The first Skylark was an unguided single-stage rocket with a lone solid-rocket motor. The early models accelerated so gently that they required a 150-foot launch rail, but the design evolved into a more powerful multi-stager. The rocket was popular with young researchers in the 1960s, for within three years a doctorate student could design an experiment, launch it on a Skylark, and write up the results. "It was where people cut their teeth in aerospace," says design engineer John Turner, who began work on the program in the mid-1960s.

Although government funding ceased in 1977, the program continued commercially, with SRS taking over from Matra Marconi in the mid-1990s. Production of the motors ended in 1994, but a stockpile allowed SRS to make about a launch a year. With a success rate of 91.6 percent and only 37 failures, "Skylark is one of the most successful British rocket programs of all time," Whitfield says.

—Robin Hague

But Can You Make an Airplane That Mows the Lawn?

There's an old saying among prop-heads: Put a big enough engine on it and you can make a brick fly. Radio-controlled-aircraft enthusiasts Henry Ramos and Spiro Markozanis have pushed that envelope with an aerobatic lawnmower. Except it only looks like a lawnmower—concealed in its body is a wing with elevators; its handlebars are stabilizers. And it can't actually cut grass.

Thirty years ago, when Markozanis was a Brooklyn, New York lad of 13, he spotted Levi Jordan flying a homemade lawnmower, which Jordan had christened the Sky Cutter, at Garrison Beach. Years later, while surfing eBay, Markozanis found a Sky Cutter and posted the winning bid. He enjoyed aerial mowing so much that he started pestering Jordan for another of his designs, a flying doghouse. Jordan sold him a doghouse, mentioning that he was shutting down his business, FlyingThingz. So Markozanis, now living in Stroudsburg, Pennsylvania, talked to fellow R/C enthusiast Henry Ramos, and together they made Jordan an offer. Once his business was in their hands, the pair modified Jordan's designs to improve their performance. "The old doghouse would wobble like a sailboat on a windy day," he says. "It couldn't do loops or rolls." But after some 16 iterations they had it looping and rolling like a Pitts Special.

GEORGE MOCK

So, you got your push mower, your rotary mower, your electric mower, and now your flying mower. Note: This one doesn't actually cut the grass, and it's been known to shed a wheel.

Last year FlyingThingz sold 600 non-aerodynamic craft, including mowers, tanks, and sports cars; in the first two months of 2006 they had already shipped 200 units. "Anything that doesn't look like it's going to fly is what we shoot for," Markozanis says. "If I have a lot of requests for a flying pig, we'll build it. Say it weighs five pounds and the motor can pull 15 pounds, if you put your mind to it, there is a way to make it fly," he says. The basic principle to making such objects fly is the power-to-weight ratio. Most FlyingThingz are powered by two-stroke engines that provide a bountiful ratio of two to one.

"We can make a brick fly," Markozanis says. "That's an easy one. What I can't make fly is my mother-in-law."

—Phil Scott

IN THE MUSEUM

Airplane Meet 'n' Greet

In the darkness of an early Saturday morning last June, we met at Culpeper Airport in Virginia, the home base of my friend Charles Maples' restored 1944 Beech D17S Staggerwing biplane. Charlie and I pushed the aircraft out of its hangar and into the fresh air, and after a quick preflight, we were ready to fly to Washington-Dulles International Airport, where the National Air and Space Museum's Steven F. Udvar-Hazy Center was hosting a fly-in as part of its "Become a Pilot" Family Day. Charlie was one of more than two dozen pilots invited to the fly-in, and I was excited to be his passenger for the 35-mile hop.

At 8:30 a.m. we took off into the summer haze, and, a few vectors and 25 minutes later, we were over Dulles, the sky now bright. I had flown into Dulles many times via airliner, but this time I was arriving in style. Transportation Security Administration and airport authorities were all smiles and waves as the yellow Staggerwing passed through the security gate stationed between one of the airport's taxiways and the tow road leading to the Udvar-Hazy Center. Waving back to everyone from the Staggerwing's right seat, I felt like a movie star from the 1940s.

More than two dozen aircraft had already arrived and were parked outside the center's main hangar, including a U.S. Marine Corps Harrier vertical-takeoff-and-landing jet, an Aero Vodochody L-39 jet trainer, a Lancair, a North American Navion, a Globe Temco Swift monoplane, and a World War II-era Vought F4U Corsair gull-wing fighter. Visitors had the opportunity to enter the cockpits of many of the airplanes and ask questions of the pilots. Volunteers from the Civil Air Patrol and the Girl Scouts of America kept the aircraft display area free of litter and watched over airplanes when their pilots wanted to go inside but did not want to leave

CAROLYN RUSSO

DANE PENLAND

National Air and Space Museum director John Dailey (above), who flew in to the Steven F. Udvar-Hazy Center (left) in an Aero Vodochody L-39 jet trainer, spent the day explaining the aircraft's cockpit display to young visitors.

ARTIFACTS

Baby Bell

The Bell Model 30 Ship 1 helicopter, now on display at the Steven F. Udvar-Hazy Center, is the first of three prototypes that led to the ubiquitous bubble-canopy Bell 47, which was known for transporting injured soldiers during the Korean War. Built in 1942, the Model 30 made its first flight on December 29; during the next year, the prototype crashed twice during test flights, and each time the tail boom had to be rebuilt. A single 160-horsepower engine powered the craft, which has a steel-tube airframe, tricycle undercarriage, and rotor blades of laminated wood. In 1964, the Franklin Institute in Philadelphia donated the Model 30 to the Smithsonian Institution. The Model 30's descendant, the Bell 47, is known for its stability and ease of handling. Beginning in 1946, Bell manufactured more than 4,000 of the type, and nearly 1,000 are still registered with the Federal Aviation Administration.

A sleek fiberglass Lancair, flown by pilot Michael Young, was a favorite with visitors (right).

The author will never forget her experience flying into Dulles in the right seat of a 1944 Beech Staggerwing biplane (below).

CAROLYN RUSSO (2)

their aircraft unattended.

The Staggerwing received a steady stream of visitors who wanted to see the regal biplane up close. Charlie refers to the Staggerwing, first produced in 1933, as the "Learjet of the '30s" because of its popularity among corporate executives of the day, who fancied the biplane's 200-mph cruising speed. They probably also liked the luxury of the craft; the Staggerwing's back seat can seat three abreast (it's like "something out of a '56 Buick," says Charlie). A 450-horsepower Pratt & Whitney R-985 engine provides the Staggerwing with robust propulsion up to 15,000 feet.

DANE PENLAND

Event organizers had set up an array of activities for all ages inside the hangar. Adults could listen to curators talk on various artifacts while children learned about the parts of an aircraft from Museum docents, who took turns dressing up as television cartoon character Jay Jay the Jet Plane. By day's end, more than 5,500 people had stopped by, and the inaugural event was deemed so successful that fly-in organizer Margy Natalie, who is the Udvar-Hazy Center's aerospace educator-in-residence, says that a second "Become a Pilot" Family Day has been planned for June 17 (for more information visit the Web site *www.nasm.si.edu* or call 202-357-2700).

Visitors who stayed until the end were rewarded by the sight of the fly-in aircraft departing Dulles along with scheduled airliners. By 2:30 p.m., Charlie and I were back in the Staggerwing, and we took our place in line with a few United Airlines Boeing 737s and several Independence Air Bombardier CRJ-200s. We had a long, slow taxi to the runway, but after getting clearance for takeoff, we broke ground and as we climbed to 2,500 feet, we found ourselves with a lovely view of the center. How many of the visitors will return in June with a few flying lessons under their belts? I know I will.

—Caroline Sheen is Air & Space/ Smithsonian*'s editor of photography and illustrations.*

VISITOR INFORMATION

April 6 "Growing Up With General James Doolittle: An Evening With Jonna Doolittle Hoppes." Free tickets can be obtained online through *www.nasm.si.edu*; for more information, call (202) 633-2398. Lockheed Martin IMAX Theater, Museum on the Mall, 8 p.m. to 9 p.m.

April 8 Family Day: "Telescopes, Telescopes, Telescopes." Steven F. Udvar-Hazy Center, 10 a.m. to 3 p.m.

April 11 Exploring Space Lecture: "Our Home in Space—the Sun-Earth System." Free tickets can be obtained online through *www.nasm.si.edu*; for more information, call (202) 633-2398. Lockheed Martin IMAX Theater, Museum on the Mall, 8 p.m. to 9 p.m.

April 15 Family Day: "Explore the Universe." Museum on the Mall, 10 a.m. to 3 p.m.

May 9 Exploring Space Lecture: "Unraveling the Mysteries of the Earth's Changing Ice Cover." Free tickets can be obtained online through *www.nasm.si.edu*; for more information, call (202) 633-2398. Lockheed Martin IMAX Theater, Museum on the Mall, 8 p.m. to 9 p.m.

May 16 "An Evening With Vern Raburn, Founder of Eclipse Aviation." Free tickets can be obtained online through *www.nasm.si.edu*; for more information, call (202) 633-2398. Lockheed Martin IMAX Theater, Museum on the Mall, 8 p.m. to 9 p.m.

May 20 Family Day: "Celebrating the Early Years of Airmail." Museum on the Mall, 10 a.m. to 3 p.m.

Curator's Choice
Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at the Steven F. Udvar-Hazy Center in northern Virginia. Meet at the nose of the SR-71 Blackbird at 12:15 p.m.

Apr. 6, Vega spacecraft; Apr. 20, Jerrie Mock's 'round-the-world solo flight; May 4, quarantining returning astronauts; May 18, FB-5 fighter.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.si.edu *or call Smithsonian Information at (202) 357-2700; TTY: (202) 357-1729.*

50 Feet, 600 Knots

COURTESY DRURY WOOD

NORTHROP CORPORATI
NORAIR DIVISION

MEMORANDUM

Subject: Blue Angels Familiarization Flights
From: Engineering Test Pilot
Date: 5 June 1962

When you told me to fly with the angels last week, I figured it out for myself that you weren't telling me to get lost, but that it was the Navy Blue Angels to whom I should demonstrate the T-38. I got hold of marketeers Close and Couberly and accompanied them in a Piaggio transport to Ontario International, where the Angels were coming in at noon Thursday.

They came in at about 12:30, and even with the small crowd to greet them, they still made their arrival look like the conclusion of an airshow. They taxied into the chocks nose-on-tail, and no one shut down an engine until they were all in position. When the leader, Ken Wallace, put on his hat, the other five put on their hats. When Ken got out of his airplane, the other five got out of their airplanes. When Ken put on his sunglasses, the other five put on their sunglasses. What else they do together I haven't the slightest idea.

After everyone was out of the cockpits, they formed a group of tailored blue flightsuits and shiny boots for a post-flight discussion. From this group of shiny boots and suits, we snared Lieutenant Commander Ken Wallace, Captain Doug McCaughey, U.S. Marine Corps, and Lieutenants Lew Chatham and George Neale, stuffed them aboard the Piaggio, and headed for Edwards.

In addition to using our airplane, the plan was to borrow a T-38 from the Test Pilot School and another from Fighter Operations so that they could at least fly a three-plane formation to determine the desirability of the T-38 for their shows. We lined up the three airplanes and started out from the Norair installation at Edwards with T-38 551, with Lieutenant Commander Ken Wallace as pilot and yours truly as instructor pilot. As we taxied by the line at Fighter Operations, Doug McCaughey tacked onto our right wing, and I do mean tacked on. He could not have been more than one foot away from our wingtip on the way to takeoff position. Lew Chatham and his airplane were not able to leave the line because of airplane difficulties.

Air Force Operations would not allow a formation takeoff, for which I shall be eternally grateful; the join-up after takeoff happened too soon for comfort for me as it was. Doug socked in on the right wingtip and stayed glued there for the next 30 minutes while Ken did loops, rolls, reversals, and inverted flight. I would not have minded at all if he had started at any altitude above 50 feet. It was amazing to me the confidence that these two gentlemen displayed. Here they were in an airplane they had never seen before, never flown before, and in which they had only the minimum of cockpit familiarization, doing acrobatics at 50 feet and 600 knots.

After the first 30 minutes and I still had not ejected, I figured that I might be able to survive the rest of the familiarization flights. I seriously considered phoning you to ask for a risk fee before assuming the responsibility of any more Angel checkouts.

Captain McCaughey's airplane flaked out after the low-altitude acrobatics with a

double generator failure. I had assured them that this absolutely could not happen. Ken and I did not know this, of course, because Captain McCaughey had lost his radio, so after fiddling around for a little while longer we went back to Edwards. On the approach to the airfield, Ken asked what the landing approach speeds were. I told him 165 knots for the base leg and 140 on the final. After the past hour, it was no surprise to me that he held 165 knots on the base leg and 140 on the final. The landing was almost as good as I could have done.

The next day we again attempted to arrange a three-plane formation, but the other two airplanes fell through and we wound up having just ours. I am not so sure that I wasn't pleased at the news. Nonetheless, the object of the game was to give each of the Angels a ride in the airplane, so I proceeded to give Lew Chatham a cockpit checkout, and we were airborne.

Lew is the solo pilot for the Angels. He takes care of that gap in time when the formation is performing a reversal to come back over the field for another maneuver. He does things such as eight-point rolls, four-point rolls, loops off the deck, inverted flight, Cuban Eights, and a brand-new one that I never heard about, vertical shear.

After a few minutes in the air, Lew appeared to be pretty familiar with the airplane. In fact, he was more familiar with it after 15 minutes than I was in 15 hours. We went back to the dry lake at Saltdale and proceeded to put on an airshow with no audience except the terrified instructor pilot in the back seat. I was bound and determined not to cry Uncle, and held myself firmly in check (and other places) until we started that maneuver called the vertical shear. This involves raking the field at 600 knots, rolling into a 90-degree bank to the left, and then pushing zero-G. This is a brilliant maneuver if executed correctly, but has a limited timespan because no matter what the airspeed, the airplane is not capable of forgetting those little things called G, lift, and all that jazz. When it appeared that we were in imminent danger of striking the lake bed (less than one wingspan) and still knocking off 600 knots, I chickened out and croaked, "Roll out or we are going to hit!"

After we were level, his coarse laughter rang in my ears as he said, "Haw, haw, you thought we were going to crash."

My immediate reply was "You're goddamned right I did."

To sort of square the tables, I then took control of the airplane and said I was now going to show him something that he had never seen before. The look of disbelief on his face changed to amazement as I pulled the airplane up into a 90-degree climb at 600 knots with both afterburners roaring. At about 15,000 feet, I retarded the throttles to idle and told him to look in his rear-view mirror. With that, I clasped both hands behind my head and told him not to touch the controls under any circumstances.

As the airspeed indicator crept down to zero, he could contain himself no longer and whispered repeatedly over the intercom, "Jeezus! Jeezus! Jeezus!" The airplane slowly arced over the top and in the ensuing quiet I could hear "Jeezus! Jeezus! Jeezus!" I figured that we were now square, and we resumed his familiarization period. His landing was every bit as good as that of Lieutenant Commander Wallace's.

My next passenger was Lieutenant George Neale, whose demonstration was essentially the same as that of Lieutenant Chatham's, with less vigor.

A summary of their comments would reveal that each and every one was enthusiastic about the airplane's performance, visibility, control, acceleration, and everything else you can think of that is necessary, except that they were not too fond of the airplane's longitudinal force gradient. It seems that for their demonstration flights, they crank in full nose-down trim and fly the entire performance with a built-in pull force of at least 30 pounds. The purpose of this I do not know, except to say that it certainly takes care of any stick slop that may exist.

That is about the whole story, except to say that Thursday and Friday were certainly unforgettable. I treasure the memory so much and believe the experience to be so valuable that when the next team comes around, I would like for the other Northrop pilots to share these pleasures with me.

D.W. Wood
Engineering Test Pilot
R3951 Ext. T/L

DWW:nr

Blowing Off Steam

"Well, how does she look?" Bill Besler asked observers at the Oakland Airport one morning in 1933. That he could be heard distinctly, though he spoke from the cockpit of a biplane 200 feet above their heads, spooked the crowd. Besler then throttled up over San Francisco Bay, leaving a wisp of water vapor condensing in the sun—and a throng of squinting witnesses to the first documented flight of a controllable airplane powered by steam.

And one of the last. Three times the blue Travel Air flew silently through the black-and-white frames of newsreel footage of the event. Then, with the propeller spinning in the wrong direction, Besler landed his Steamplane and taxied backward off the runway. After one flight the next day, he never flew it again.

"He never believed in it as a commercial aviation product," recalls aviation writer Walter Boyne, a former director of the National Air and Space Museum who interviewed Besler in 1962. "He toyed with ideas for more advanced steam engines for aircraft use, but never really thought it would take place."

The brothers William and George Besler acquired the automobile manufacturer Doble Steam Motors of Emeryville, California, around 1930. Besler was in the railroad business; the Doble steam car used a powerplant lighter than any in its horsepower range. Modifying the design for rail applications, the Beslers sought to distinguish the engine from conventional steamers, perceived as heavy and explosion-prone. James Crank, a Bay-area engineer and steam historian who worked with Besler in the 1960s, asked him about the impetus for the Steamplane. "If you had just obtained ownership of the patents for the lightest, most efficient, most compact steam power system in the world," Besler said, "how would you demonstrate this with the most dramatic impact?"

NASM (SI NEG. #97-16201)

A steam-powered Travel Air wowed a California crowd in 1933.

Besler borrowed a Travel Air 2000 from the Boeing School of Aeronautics and removed the Curtiss OX-5 engine. At 400 pounds and 90 horsepower, the eight-cylinder OX-5 was the original equipment of civil aviation following World War I. "Besler's goal was to make a powerplant that was as powerful and weighed as much as the original gasoline engine," Crank says. The result: a two-cylinder, V-type steam engine with only 10 moving parts, weighing just 180 pounds but producing over 150 horsepower. Though the boiler and condenser added 300 pounds, the horsepower-to-weight ratio was superior to that of the OX-5. And Besler's design retained a steam advantage: the capability to flip-flop valve timing and reverse propeller rotation.

On April 12, 1933, a small crowd fringed by Hearst News cameras gathered on the grass at the Oakland airport. The absence of engine noise when Besler opened the throttle for takeoff bluffed even Boeing supervisor Allan Bonnalie, a representative of the Fédération Aéronautique Internationale who documented the flight. "It was this observer's impression that the airplane was not getting up speed enough," he wrote. But the Travel Air climbed robustly to 200 feet and banked over the bay in excess of 100 mph. Conversing with startled spectators, Besler made several flyovers before lining up to land. As he lost altitude, the propeller slowed, then reversed and spun rapidly at touchdown. In the first recorded use of thrust reversal, the Travel Air rolled to a stop in less than 60 feet. After two more flights, Besler threw the prop into reverse on final approach. The airplane plunged almost vertically, but just before pancaking onto the ground, Besler swapped the valve timing and the nose rose slightly for a perfect landing and came to a stop in a cloud of steam directly before the cameras. The instant publicity bagged Besler Systems lucrative contracts, including one to build the renowned Blue Goose railcar for the New Haven Railroad.

The engine was mothballed until 1937, when a Japanese colonel offered $25,000. Since Besler saw little potential for steam-powered aircraft, Walt Boyne says, "he was surprised when Japanese personnel wanted to buy it. He sold it to them somewhat with the feeling that he was taking advantage of the situation, that they were buying a dead-end." (A post-war attempt to retrieve his prototype was unsuccessful, but in the 1960s Besler built a replica that is now at the National Air and Space Museum.)

Jim Crank, who has spent decades researching Besler's innovative steam patents, offers this blunt assessment: "It was no advancement of the technology of aircraft propulsion—just the opposite. The gasoline and diesel internal combustion engine are a perfect match for driving an airscrew on an airplane. There, you want a constant speed, and the engine can be designed to be the most efficient at that speed."

Nevertheless, in the wake of Besler's success, pop periodicals of the 1930s envisioned "airways of the stratosphere" filled with colossal steamplanes. "Besler paid no attention to the ravings of the press," Crank says. "For him it was a one-shot deal and, for his goals, it succeeded."

—Stephen Joiner

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The Steinhausen engineers set out to make the thinnest, lightest, most beautiful watch in history. After five grueling years of constant research, development and testing, they introduced the Dunn Horitzon Rasierer. Dunn Horitzon is German for "Thin Horizon." "Rasierer" refers to being razor-thin. At less than two millimeters thick, you can't buy a slimmer model that includes a two-digit calendar. The Europeans lauded it for its sophistication and aesthetic look and design – it was one of the top attractions at the Basel Convention for watches and clocks in Switzerland (the most important annual clock and watch show worldwide for the past 34 years). Italian art schools are using the Dunn Horitzon as an example of the perfect design model. The Japanese praise the Dunn Horitzon for its quality and sophisticated design. And the American consumer paid the ultimate compliment by making it one of our top-selling timepieces.

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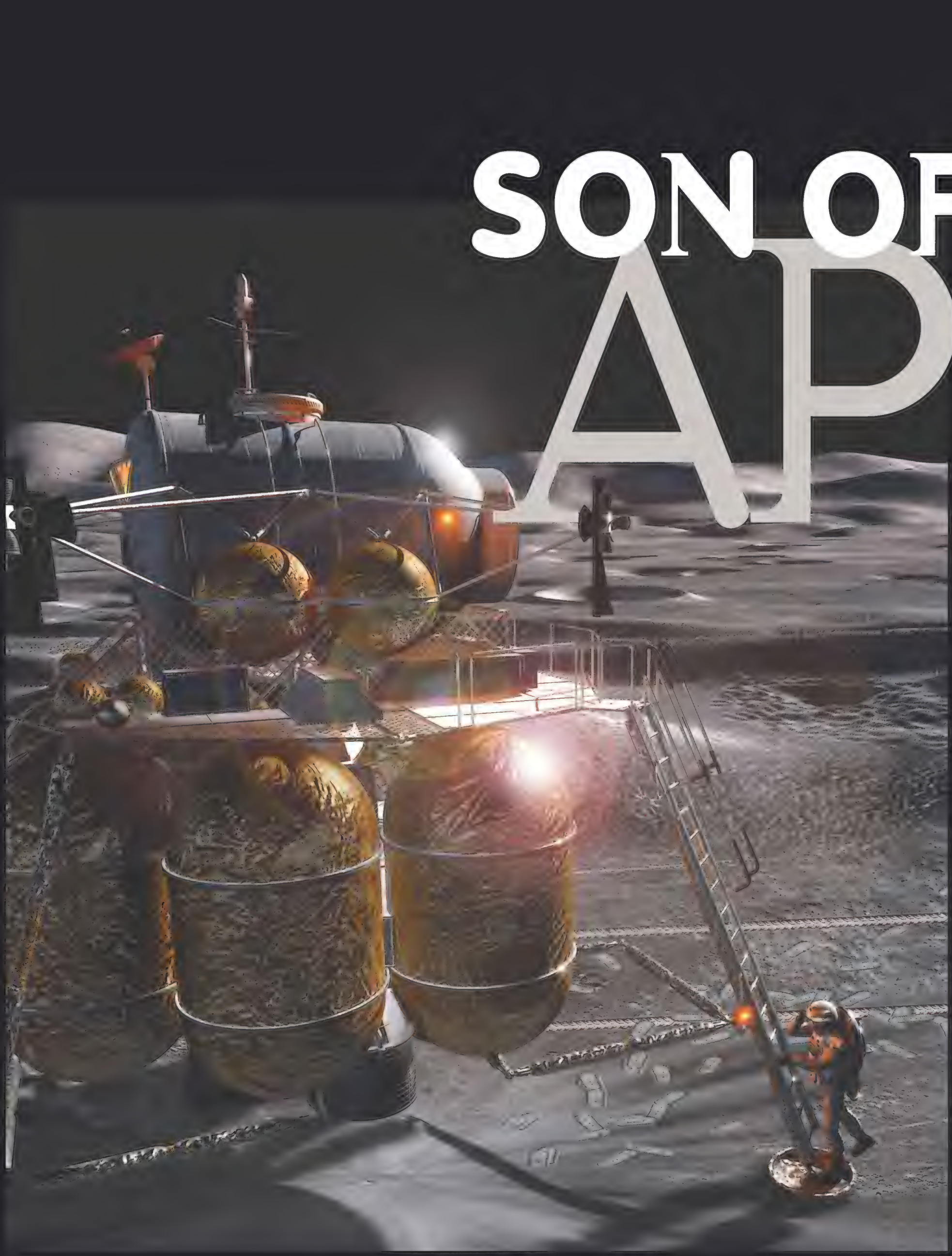

SON OF
AP

QLLO

The next lunar lander will be a giant leap ahead of the first.

BY TONY REICHHARDT

ILLUSTRATIONS BY PAUL DiMARE

Living and working in the most remote office in the solar system, the next moon-bound astronauts will rely on a 21st century lunar lander with conveniences only dreamt of by veterans of Apollo.

Dave Scott, who visited the moon in 1971, thinks the next generation of lunar pilots will have it much easier than he did. He likens his Apollo 15 landing to "the old barnstorming days, when guys used to take these old World War I airplanes and land in a farm field, in the grass, with no lights, and trees all around."

The next lunar landing, he expects, won't be nearly as seat-of-the-pants. "Everything will be wired. When they come down the line the guidance is going to be better, the knowledge of the surface will be better." And, it goes without saying, the new vehicle is expected to be a great improvement over its predecessors.

There are great reservoirs of wisdom among the veterans of the Apollo program. At 73, Scott still keeps his hand in the game as an aerospace consultant. So do some of the engineers who built his lunar lander at Grumman Aerospace back in the 1960s.

John Connolly made pilgrimages to Bethpage, New York, where Grumman is based, to seek the counsel of these veteran engineers before he moved from NASA headquarters in Washington, D.C., to the Johnson Space Center in Houston. There he will coordinate the team creating conceptual studies of the new Lunar Surface Access Module.

"Some people, their heroes are astronauts," says Connolly, as we're standing in the National Air and Space Museum in Washington, next to a squat, four-legged contraption that ranks among the great engineering triumphs of the 20th century: The Apollo Lunar Module, or LM. "The guys who dreamed up this ugly flying vehicle are my heroes."

Six Apollo landers, including Dave Scott's *Falcon*, are now on the moon, having transported astronauts there between July 1969 and December 1972. A handful of others are in museums around the United States. This particular vehicle, LM-2, never traveled in space. It didn't need to, because the first LM checked out so perfectly during an orbital test in January 1968 that a second test was deemed unnecessary.

"These guys [the Grumman engineers] in many ways pulled off the impossible," Connolly says. "They built a machine that had never been imagined before. Not only did they build it, but it worked perfectly every time."

That's a big achievement to follow. The new LSAM, if the schedule holds, will carry astronauts back to the moon in 2018, half a century after the first lunar voyages.

"I was absolutely a child of Apollo," Connolly says. "As a nine-year-old, I was the kid sitting in front of the TV with my nose 12 inches from the black-and-white screen watching Neil and Buzz walking on the moon. I had all the models of the Saturn V and the LM and everything else that day."

He turned that fascination into a NASA career, and counts himself lucky to be "working on things that very few people get the honor to work on." Yet much of his career has been spent in the bureaucratic backwaters. While NASA focused on the shuttle and the space station, Connolly and a small band of forward thinkers at Johnson conducted study after study of missions that could get the agency back to the moon if it ever got the call. There was the First Lunar Outpost concept of 1992, and the Human Lunar Return of 1996—a cut-rate, let's-just-do-it scheme that would have put two space-suited astronauts into an open-cockpit moon lander that looked unnervingly like a rocket-powered jet ski.

None of these plans went anywhere, of course. "There were a number of years where 'exploration' was a dirty word at the agency," Connolly says.

Then came the 2003 *Columbia* accident, and a dramatic, White House-mandated change of course. No more circling Earth. Returning people to the moon, and using it as a training ground for Mars, would be the space agency's new plan. So for the past two years, Connolly and his colleagues at NASA headquarters have been developing the Architecture (a word NASA uses with the same reverence fundamentalists accord to "Scripture") for accomplishing their new mission.

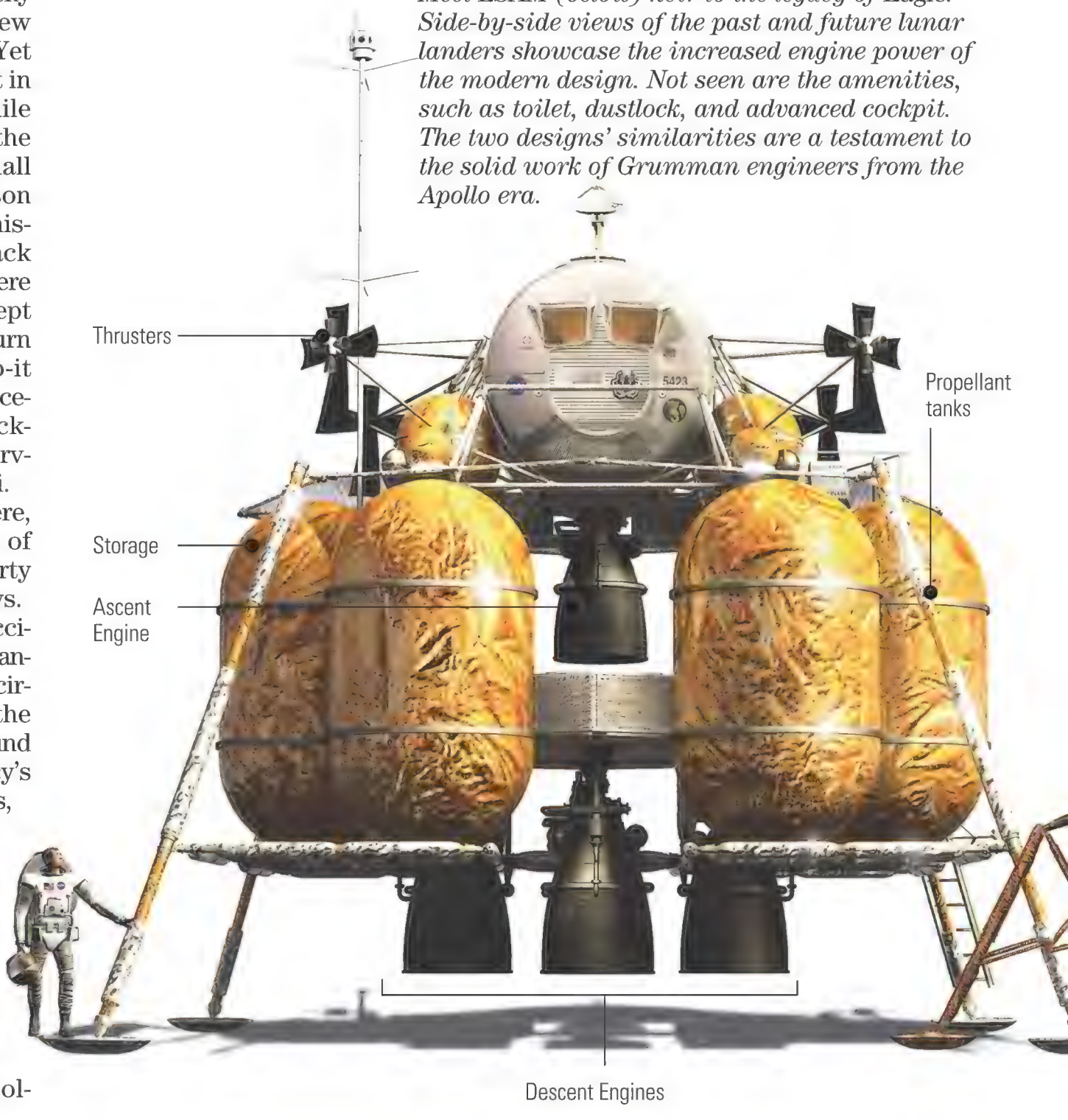
The Architecture calls for sending four astronauts at a time to the lunar surface, compared with Apollo's two. Instead of spending three days on the moon, they'll stay a week. And rather than being confined to a narrow band of landing sites around the lunar equator, they'll be able to land anywhere, even the poles, where scientists believe ice in the soil could be converted to fuel and drinking water.

These improvements over Apollo result largely from an advantage in rocket power. Not only are modern propulsion systems more efficient than those of 40 years ago, but NASA is also taking a different approach this time, launching the moon vehicles on two separate rockets with a combined 150 metric tons of lift. In comparison, Saturn V had 130 tons.

LSAM's additional lift power will enable it to be bigger, better, and in every way more capable than its predecessor. In cargo-only mode, with no crew, its carrying capacity will be 21 tons, more than the weight of the entire LM.

But will it look very different? No matter how many years have passed or how many studies have been conducted, the physics and engineering practicalities of landing on the moon drive the design inexorably toward what the Grumman engineers came up with decades ago. "We might have wanted the LSAM to look like the *Millennium Falcon*," says Connolly, with a trace of wistfulness. "But it will probably look like the Apollo LM."

Meet LSAM (below) heir to the legacy of Eagle. *Side-by-side views of the past and future lunar landers showcase the increased engine power of the modern design. Not seen are the amenities, such as toilet, dustlock, and advanced cockpit. The two designs' similarities are a testament to the solid work of Grumman engineers from the Apollo era.*



The best way to do lunar exploration would be a "direct-direct" option, straight from Cape Canaveral to the surface of the moon. But that requires a rocket that can lift 200 tons to Earth orbit, says Connolly, and "we're just not going to build a launcher that big."

The LSAM lander will go on a large rocket, along with the Earth departure stage needed to reach the moon. A smaller rocket will then deliver the crew (in an Apollo-style capsule called the Crew Exploration Vehicle) to Earth orbit. There the CEV and LSAM will link up, the departure stage will fire, and three days later the still-joined vehicles will enter a 60-mile-high lunar orbit, from which the LSAM will descend to the moon's surface. NASA calls this big rocket–small rocket combo its "1.5 launch" option.

The study team quickly settled on a two-stage lander, same as that in Apollo, with a descent stage topped by a smaller ascent stage that brings the crew back up to lunar orbit following their adventures on the surface. In orbit, they'll return to the CEV capsule for the journey home.

Here the new plan again diverges from the old one. There will be no Mike Collins waiting in lunar orbit to greet Neil and Buzz—the CEV will be left unattended.

Separating the new lunar module into pieces will be even more important in 2018 than it was in 1969, when NASA's goal was just to land astronauts on the moon and bring them back safely.

This time, the missions are only prep work for something far more ambitious—a lunar outpost where small crews will live for up to six months at a time. The early missions will likely all land in the same location, incrementally adding descent stages and other hardware that will become the building blocks for the new base.

One piece that will be especially useful to leave on the moon is the LSAM's airlock, which represents one of the most significant improvements over the Apollo LM. The moonwalkers of the 1960s struggled with the fine, powdery dust that covered their spacesuits. Back inside their tiny one-room cabin, it got everywhere—in the machinery, in their eyes, in their throats.

Scott said that moon dust even got in the connectors between the backpack and the spacesuits."You could almost hear them grind after three days," he said. He ranks dust as "the major problem for a long stay."

Mike Griffin, who became Administrator of NASA last year, was particularly eager to liberate the next generation of moonwalkers from lunar dust. So the Architecture team added an airlock, or dustlock, to the LSAM that will function like a mudroom in a suburban home—a place where astronauts can remove their dirty things and avoid tracking the mess inside.

Airlocks have other advantages. With an airlock, the main cabin always stays pressurized, and the airlock acts as a transition zone between the shirtsleeve environment and the vacuum outside. Say all four astronauts are on a moonwalk and one suit develops a leak. Without an airlock, all four have to come inside at once and stay there, since any later entrance would expose the unprotected crewmember to the lunar vaccum.

The outer structure of the LSAM cabin will likely be a cylinder, similar to the large pressurized cans that make up the International Space Station's living and working spaces. The airlock could be a smaller, attached cylinder, though it needn't be.

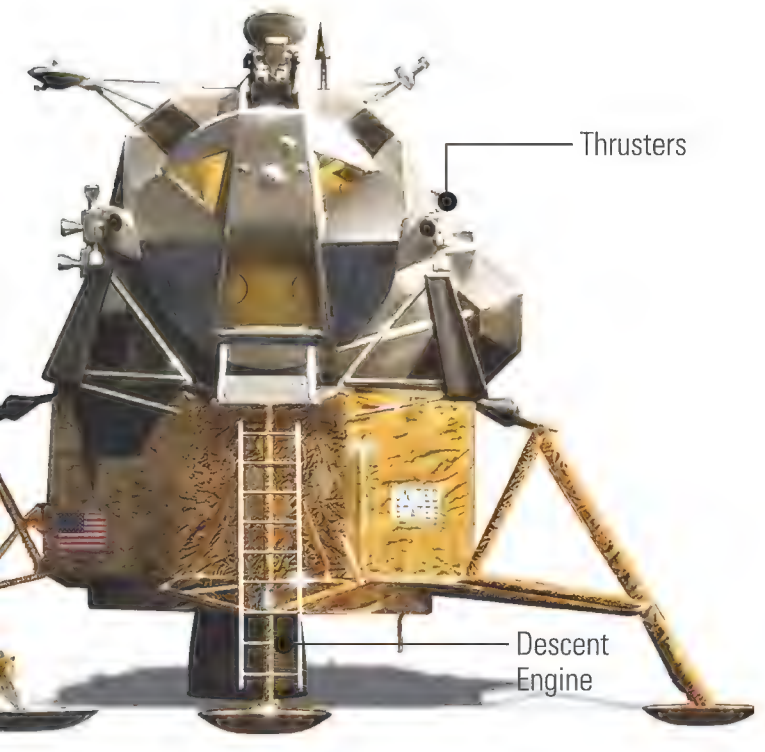
In some designs, says Connolly, "we're talking about just putting an extra bulkhead and a hatch into [the LSAM] cylinder." But it might be preferable to have the airlock hatch closer to the lunar surface instead of placing it 15 or 20 feet off the ground, reachable only with a long ladder. The study team played with different options, including a kind of split-level design in which the astronauts descend a tunnel before heading out the airlock. The spacecraft's designers are still working to determine the exact configuration.

> Because the descent engines will be bigger and more powerful than the ones that flew on Apollo, engineers have had to consider the effects of a stronger blast.

As for propulsion, NASA will go with the old reliable: liquid hydrogen/liquid oxygen engines for both the descent and the ascent stages. Apollo had to make do with less potent hypergolic fuels, which ignite on contact, because they were the safest and most reliable propellants available at the time. The LSAM descent stage will use a modified version of the venerable RL10 engine, which entered service in 1963, just as Apollo was getting under way.

The descent engines for the lander have to be throttleable—by the time of touchdown, they'll produce barely enough thrust to keep the vehicle from falling to the surface in the one-sixth gravity of the moon.

Today's RL10s can throttle down to 20 percent of their full thrust, but the LSAM engines will have to do better:



10 percent. That shouldn't pose a problem, thinks Connolly, but the achievement still requires some development work, and NASA may want to test these highly throttleable engines on robotic landers scheduled to begin visiting the moon as early as 2011.

Because the descent engines will be bigger and more powerful than the ones that flew on Apollo, engineers have had to consider the effects of the stronger blast on the lunar surface. When Pete Conrad piloted his lander to a touchdown in the Ocean of Storms during the November 1969 Apollo 12 mission, the rockets kicked up so much dust that for the last two minutes of his descent, he could hardly see anything below him. Could the debris from a more powerful blast fly up and hit the lander?

Connolly's team studied the problem, even watching old videos to analyze how the dust scattered. Most of it blew horizontally away from the landing site, not straight up. Conclusion: Rocket thrust shouldn't be a danger, at least for the LSAM itself. Some still worry about blast effects on previously landed modules, since the vehicles will probably touch down close to one another.

The single engine on the ascent stage also will use liquid hydrogen and liquid oxygen, even though the combination wasn't NASA's first choice. The Architecture team originally wanted to use liquid methane fuel, in one of the lunar program's few nods to an even more distant future. Someday, when astronauts land on Mars, they'll need to live off the land as much as possible. Methane could theoretically be extracted from the atmosphere and turned into rocket fuel. So if the LSAM used methane engines, NASA could get early practice with a technology applicable to Mars.

The trouble is, no one has flown a methane rocket in space. A French-Russian demonstration project called Volga concluded last year that the technology looked promising, and a couple of companies have tested small-scale engines. But that's about it. Methane engines would have been one of the bigger leaps in the Architecture, and in the end NASA decided it was too big of one. The ascent engine

absolutely, 100 percent, no kidding, has to work perfectly on the moon. Otherwise the astronauts are stranded.

Before trusting methane engines on the moon landers, NASA would have wanted years of experience flying them on the CEV. But with the CEV's debut planned for as early as 2010, there isn't time to develop such an important technology. So, reluctantly, NASA gave up on methane.

The decision to go with hydrogen fuel—and lots of it, since the LSAM will need to shift the plane of its orbit as much as 90 degrees to reach polar landing sites—influences other aspects of the design. The most striking example is the size of the fuel tanks. Hydrogen takes up more volume than denser fuels, so the descent stage tanks alone will be taller than the entire Apollo descent stage.

The 1960s lander was "a marvel of minimization" that strained the ingenuity of its builders, says Connolly. "They had to whittle away at every piece of metal on the vehicle to make it as light as possible." Current designers have more mass and volume to play with, so the LSAM will be substantially roomier than its predecessor, more like an RV than a minivan.

Connolly's team hasn't devoted much thought to amenities, but he predicts a few improvements that will mean a lot to future astronauts. They won't have to relieve themselves in bags, for example—the LSAM will have some kind of toilet, even if it isn't as elaborate as the one on the space station. It might be something like the small, portable job the Russians have used on their Soyuz spacecraft for years. And whereas the Apollo astronauts ate strictly cold fare during their time on the moon, the LSAM should have a food warmer.

Last year, a group of astronauts and engineers at Johnson received a modest NASA grant to brainstorm what accommodations might be needed for long-term living on the moon. The group built a mockup of a lunar habitat in one of the center's warehouse-like buildings in Houston, and invited a few veteran astronauts and scientists with Antarctic experience to attend their Lunar Habitation Systems Workshop. Three-time shuttle astronaut Mario Runco led the exercise.

One feature Runco is especially keen to include in a lunar module is windows. "You're talking to the windows-in-space guy," he says, and he's not

A new generation of lunar ground vehicles may go much farther than Apollo 17's record round-trip drive of 12 miles. The lunar missions are billed as steps toward a manned excursion to Mars, as well as contributing to planetary science.

joking. On the shuttle, where astronauts tend to eat on the run, he once made a point to spend a luxurious 40 minutes eating his spaghetti dinner while looking out the windows of the world's highest rooftop restaurant.

Because glass is heavy, the weight-conscious Apollo LM engineers could afford only tiny triangular portholes. LSAM's designers can probably do better than that, but will they? "Engineers reluctantly put in windows," laments Runco. "[And] the first things to go are the things for the crew."

On more than one landing, however, the LM came down in a crater, so it ended up tilting at a slight angle. Nothing too serious, but that may have been luck.

But windows are more than just entertainment: Lunar pilots will surely want to see outside while landing on the moon. That is, if they're the ones actually doing the piloting—which is a matter of some debate.

Here's how they did it in Apollo: The two astronauts stood during their descent to the lunar surface. Early in the landing sequence, the LM's computer handled all the necessary course corrections, even managing the dwindling fuel supply. Radar on the lander kept the computer updated on its position.

Then, just a few minutes before touchdown, the LM pitched over so the astronauts could look out the window and get their first good look at the landing site. If the commander liked what he saw, he could stay with the course the computer had chosen. He could nudge the path slightly. Or he could take full manual control and fly the landing himself, as Neil Armstrong did on Apollo 11, when he saw the *Eagle* heading for what looked to him like a field of boulders.

The Apollo landings were a joint effort between primitive (though then state-of-the-art) computers and very skilled pilots, and all six missions came down safely. On more than one landing, however, the LM came down in a crater, so it ended up tilting at a slight angle. Nothing too serious, but that may have been luck. Shortly after his dust-blind Apollo 12 landing, Pete Conrad told mission control he had come in guided only by instruments, adding: "It's a good thing we [trained in] a simulator." Weeks later, during his debriefing, he admitted, "I couldn't tell whether there was a crater down there or not."

When it comes to knowing their landing sites ahead of time, the LSAM pilots should have their Apollo forefathers beat hands down. The Lunar Reconnaissance Orbiter, scheduled to launch in 2008, will have long since mapped the moon's entire surface. Potential landing sites should be mapped to a resolution of a foot or two. Additionally, robotic landers may have photographed every rock and gully in the vicinity before the astronauts arrive. And advanced sensors on the LSAM, including laser ranging devices, could offer real-time hazard detection that cuts the chances of coming down in a bad spot to practically zero.

Connolly agrees that the tools will greatly improve landing. And he still pictures an astronaut at the controls in those final moments before touchdown. Landing on the moon is "very hard to do automatically," he says. "It's something, however, that pilots are very good at. In fact, picking out level, safe landing sites is sort of the whole idea of piloting."

That's way too old school for Missy Cummings, director of the Humans and Automation Laboratory at the Massachusetts Institute of Technology in Cambridge. Under contract to the nearby Draper Laboratory, Cummings has come up with designs of cockpit displays for the next generation of lunar landers. Both Draper and MIT are experienced in this area, having designed the guidance system and computers for the Apollo program, and Draper did the new work under a grant from NASA's exploration office.

The "glass cockpit" that Cummings envisions is light-years beyond Apollo's clunky switches and dials, beyond even current military fighters. The lunar astronauts would see an artificial view of their landing site from the surface as well as from above. Easy-to-interpret displays will show their trajectory, possible hazards, and remaining fuel. Computers would synthesize all the information, leaving the pilot to intervene only if something went wrong.

If the system is designed right, says Cummings, "anybody, anywhere, anytime should be able to control the lunar lander." The operator wouldn't even have to be on board. "You do not need 1,000 carrier landings or the Right Stuff to be a good lunar lander pilot," she maintains.

Lest anyone think this opinion comes from some pale computer geek who's never been closer to pilots than Row 12 of the red-eye to Boston, a brief word on Professor Cummings' background: Before she got her Ph.D., she was one of the first female naval aviators to fly the F/A-18 Hornet. Today she spends much of her time on the problem of controlling networked unmanned aerial vehicles (UAVs).

Because NASA also wants the LSAM to be able to land with no crew on board, delivering supplies in "cargo mode," Cummings says the agency's experience with remote-controlled landings on Mars is as relevant as the exploits of the Apollo astronauts. Her fear is that astronauts won't stand for some ground controller "piloting" the LSAM from afar. The same tension exists between Air Force pilots and UAVs, she says. "I was a fighter pilot. I was the most elite of the elite. And we're the ones who are most resistant to this change."

On this issue, Dave Scott, the Apollo 15 commander, comes down somewhere in the middle. "Airliners have had auto-land capability for a long time, but they still have the pilot up in front," he says. "So I would say if you get a lunar lander with an auto-land capability, you're still going to have the pilot looking out the window."

The question of who will pilot the

Leaving useful pieces behind for future visitors who will establish a permanent camp, the ascent stage blasts from the lunar surface.

LSAM doesn't need to be settled today, though. Right now Connolly has his hands full with big-picture design questions, particularly those that affect near-term development of the CEV and launch vehicles.

So Connolly consults with those who have been in his shoes—his predecessors, now retired from Grumman. "They are thrilled that NASA is coming back and talking to them," he says. "They are probably as excited today about going back to the moon as they were when they built this machine."

After posing with them for group pictures and hearing their war stories, Connolly would come back to asking them the same question. "How did you pull this off? How did you make this vehicle as reliable as it was?"

One way the LM engineers ensured quality was by "extensive, extensive testing," and Connolly wants to know how much he should budget for his test program.

That's another crucial difference between the 1960s and today: money. Once the Apollo engineers got deep into their work, the money just kept flowing, and there was little doubt NASA would follow through on its plan to reach for the moon. Could anyone make the same claim in 2006?

Having worked on more aborted return-to-the-moon plans than he can easily count, Connolly can only hope—or maybe it's better to say have faith—that this lunar lander will actually come to pass, just as the Architecture says it will.

Le Air

The airplane may not have been invented in France, but it certainly got a lot lovelier there.

by Bettina H. Chavanne

PATRICE HAMMONNET, 38, A TALL MAN with little round glasses, would like the world to know that aviation was born in France.

"You've heard of Clément Ader, right?" he asks. Ader built the Eole, a steam-powered monoplane with wing-warping, and made a 160-foot, fairly uncontrolled, low-level flight in it on October 9, 1890, 13 years before the Wrights' first powered flights.

"And the word '*avion*'—do you know where this comes from?" The Avion was the second aircraft Ader built and flew. " '*Avion*' originally stood for '*appareil volant imitant l'ouiseau naturelle*,' " he declares proudly. Roughly translated: a flying machine that imitates a bird's natural flight. "And that is French!"

Hammonnet is a member of the French aircraft restoration group Memorial Flight, and his perspective—that "France" and "aviation" are synonymous—is one shared by pretty much everyone at the Ferté Alais airshow, held in the tiny French village of Cerny. Every May since 1974, fans of European (especially French) aviation have gathered at the remote grass airfield here, about 40 miles south of Paris, for an airshow focused on antique aircraft.

For most Americans, aviation history begins with the Wright brothers.

CAROLINE SHEEN (2)

The Ferté Alais airshow welcomes all forms of military transport from both world wars (left). Above: Airshow participants go back in time, albeit slowly, in a Blériot XI 2 (right) and a Morane-Saulnier AI type XXIX.

But the French have their own brothers: Joseph and Jacques Montgolfier, who in 1783 sent two people off on the world's first manned flight: a seven-mile trip in a hot-air balloon. Ever since, the French have been ardently devot-

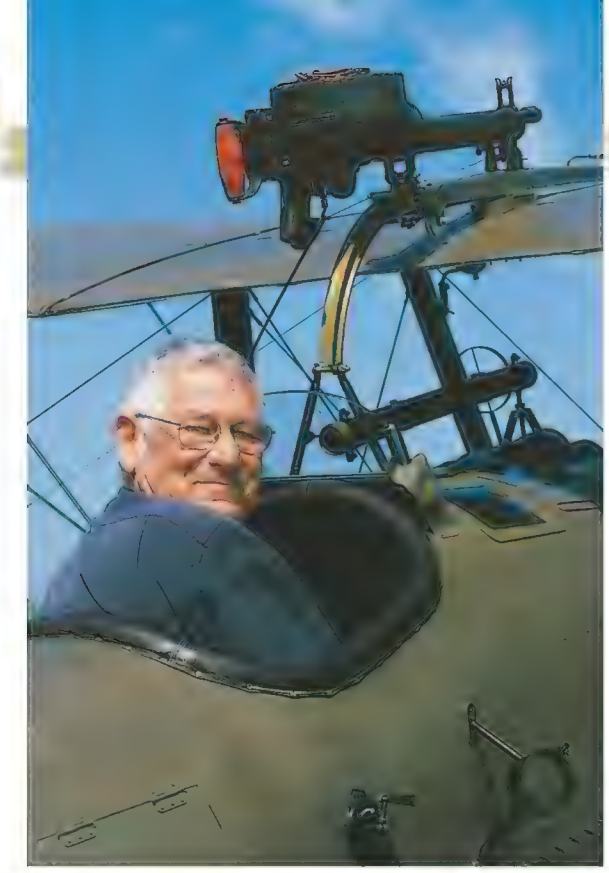
show

ed to their nation's aviation history.

The Wrights' 1903 flights only ignited the imaginations of the French, who had been developing heavier-than-air craft for years. In the early 1900s, a number of French designers threw their hats in the ring—brothers Gabriel and Charles Voisin, Alberto Santos-Dumont, and Armand Deperdussin, to name a few—with results ranging from moderate success to breaking up over (and in) the Seine.

Largely a tribute to French aviation, the Ferté Alais airshow (named after a nearby town) was started by local pilot Jean-Baptiste Salis, who died in 1967. His family, together with other members of the Jean-Baptiste Salis Association, manage the airfield, and used it to stage the airshow itself. In 1997, French publishing giant Larivière took over management of the show (the Salis association continues to contribute pilots, aircraft, and acts). Since then, the entry fee has soared to 26 Euros—about $31 per person—which angers the traditionalists. Among them is Memorial Flight, an organization of 30 volunteers who restore vintage airplanes to flying condition. Though the group rehabilitates its antiques in a hangar adjacent to the Musée de l'Air at Le Bourget airport, just north of Paris, they hangar their completed craft at the Cerny Aerodrome.

Today is the day before the 2005 show opens to the public. The members of Memorial Flight tow their meticulously restored birds out to the runway. There's a Blériot XI 2, the same type in which Louis Blériot made the first aerial crossing of the English Chan-



XAVIER MEAL

Jean Salis gets comfortable in an SE5a, a British World War I fighter carefully restored by the Memorial Flight group. Opposite: Salis' association produced this faux SE5a and another for the French movie Ace of Aces.

nel, in 1909; a Royal Aircraft Factory SE5a, which was, along with the Sopwith Camel, the most successful British fighter of World War I; a Fokker DR-I tri-wing, the type made famous by World War I ace Manfred von Richthofen—the Red Baron; and a Morane-Saulnier AI type XXIX, a French aircraft that saw little combat in World War I but afterward became a popular trainer. They are all small—under 2,000 pounds—with engines capable of 80 to 200 horsepower and top speeds ranging from about 70 to 140 mph. Today the sky is low overcast and the windsock waves lazily, indicating a mild wind—perfect for getting and keeping these lightweight, modestly powered old airplanes aloft.

One of the airplanes remaining in the hangar is Memorial Flight's 1918 SPAD XIII. "Preparing the SPAD to fly is like tuning a piano," says Arnaud Mars, 31, who works full time at the Musée de l'Air, in addition to volunteering as a Memorial Flight restorer. "All the cables have to be strung and tightened perfectly in order for the SPAD to fly." Today there's no time, so the SPAD—the oldest XIII in the world and the only one still flying—stays in the hangar.

After running through the systems on his airplane, each pilot signals to the person standing at the propeller to give it a whirl. There's a marvelous sound the engine on a very old airplane makes as it "catches," then roars to life.

The first to take off is the Blériot. Its engine sputters to a triumphant start, and two Memorial Flight members hold its tail down until the chocks are removed. Mars and fellow Memorial Flight member Jean Pierre Garibaldi are at the controls. The crowd cheers as the Blériot heads merrily down the grass strip. The old airplane takes off, but a moment later bumps back onto the grass and disappears over a low slope. A few minutes later, the airplane taxis back. This is the Blériot's first flight since it was restored; its balance had not yet been adjusted to match its payload (Garibaldi and Mars). "It's just a matter of adjusting a bolt on the tailplane," says Melvyn Hissock, 48, the sole member of Memorial Flight's British contingent.

The Blériot finally gets airborne, and the other antiques follow, creating a romantic group portrait of early flight above the rolling green hills of central France. A steady drizzle soon turns into a drenching rain, however, forcing everybody to land.

The airfield is perched above farmland; trying to land here, many pilots say, is like trying to set down on an aircraft carrier. With only 3,000 feet of grass strip, pilots are advised to land a little deeper than they're used to. A number of aircraft that cannot land at the small airfield, including the jets, are based out of Orly airport, several miles to the north.

Through the rain, a glamorous-looking Dassault Flamant MD 311, a late-1940s French trainer, lands gracefully. As soon as the Flamant touches down, a shaggy sheepdog appears in the aircraft's transparent nose. The dog

OPPOSITE: XAVIER MEAL

Below left: A 1930s Leopoldoff L.7 Colibiri painted as a German fighter is used for World War I "battles" at the show. Below: A Junkers Ju 52. Opposite, below: In the foreground is a 1936 French SFCA Taupin; behind it, a Pilatus P2 dressed like a German Bf 109 and used in Raiders of the Lost Ark; *in the back, a visiting Pitts S2C.*

CAROLINE SHEEN (2)

jumps out of the airplane barking madly, only to get hopelessly wet and gummy in the rain.

After the delicate antiques have been stowed away, a no-nonsense Dassault Mirage 2000 jet interceptor appears and thunders through a low-level aerobatics routine. The afterburner is the only bright spot in an otherwise sullen sky. The sound reverberates through the airfield hangar, dramatizing the contrast between the jet above and the ancient airplanes on the ground.

The contrast between old and new is also evident in the pilots. The jet pilots are lean, compact, and dressed in neatly pressed flightsuits. The pilots of the antique airplanes are like something out of a photograph from the early 1900s, right down to the handlebar mustaches, leather caps, and goggles.

Regardless of which era the pilots are representing, the camaraderie among them is strong as they mingle in the hangar, which is now serving as something of a clubhouse for the devoted. There's a large open area of tables and a field kitchen that looks like it could serve about a hundred. Scattered throughout the rest of the space are

CAROLINE SHEEN

XAVIER MEAL

The Dassault MD 311 Flamant, a late-1940s French design, became a popular trainer.

hulking airplane skeletons and aviation odds and ends.

Every wall is covered with beautiful watercolor renderings of airplanes from important moments in French aviation history: Henri Guillaumet crashing his Potez 25 biplane in the frigid Andes mountains in 1930; Antoine de Saint-Exupéry flying a Bloch 174 to Arras during World War II.

It's a fitting setting for the painstakingly restored aircraft that Memorial Flight keeps here. The group's philosophy: "Each airplane should be absolutely identical to when it was originally built," says Mars. Group members don't hesitate to point out that their aircraft are all "original replicas"—detailed copies built around original engines—while the Jean-Baptiste Salis Association's aircraft are rebuilt with modern engines, brakes, and sometimes navigational equipment. Some start out as other types of airplanes altogether, and are altered cosmetically. "They create copies of aircraft to use in the movies," Mars says. "The public can't tell the difference, but we can."

The Salis association was formed to continue the work of its namesake. From the moment Salis received his pilot's license, in 1917, he was devoted to aviation. In 1939 he agreed to create a school for air force pilots and mechanics in the town of La Ferté Alais. World War II disrupted the school's activities, but by 1946 Salis had reopened the Cerny field as home to a glider school.

The following year, Salis established an aircraft restoration facility and museum on the grounds, laying the foundation for the association and the airfield as home to antique airplanes. After his death in 1967, his son Jean and Jean's three sons carried on his tradition of restoration and refurbishment.

ON THE FIRST DAY THE SHOW IS OPEN to the public, it is raining heavily. The field is one giant mud puddle. Planks have been laid across some of the areas to try to keep people from sinking up to their knees, but it's a losing battle. Almost everyone is covered in muck. The flying programs are put off until late afternoon.

Despite the wretched weather, the show brings in the same number of people it always has: roughly 30,000. Families come in droves, dragging happy kids with their faces turned upward to catch a glimpse of whichever airplane is making the loudest noise.

The Ferté Alais airshow is quintessentially French. Each day the show takes a two-hour break so that everyone can enjoy lunch—red wine, sandwiches on baguettes. And the show's announcer, Bernard Chabbert, provides commentary with a touch of lyricism. As three Stampe S.V.4s—1940s Belgian aerobatic aircraft—take to the cloudy sky, he declares, "These aircraft do not fly, they dance." When two World War II aircraft, a Morane-Saulnier 406 and a German Messerschmitt Bf 109, fly, Chabbert laments the loss of the French to the Germans during the 1940 Battle of France. The crowd is nearly silent as he points out that the French were sorely outmatched by their German counterparts, who were, nevertheless, just as young and scared as the French were.

Jean Salis flies a World War II Fieseler 156 Storch German reconnaissance

Right: The crowd gathers for the customary French two-hour lunch. There's red wine, sandwiches made with fresh baguettes, and no engine noise—the pilots need to eat too.

Below: This Fokker DR-1 is an "authentic reproduction"—Memorial Flight built it with original material, to original specifications, and incorporated original parts, including the Oberursel rotary engine.

aircraft, which Chabbert describes as floating on the air like a lazy grasshopper. The Storch is followed, incongruously, by an enormous Junkers Ju 52, which the Germans flew as both transports and bombers during the war. The Junkers manages to lumber into the sky without getting mired in the boggy grass.

Sunshine finally breaks through, and more and more aircraft line up to make demonstration flights. World War I aircraft stage dogfights, and World War II craft reenact key moments in combat, complete with flaming bombs and low-flying P-51s. Toward the end of the show, the Mirage 2000 returns, this time looping and rolling to the *Top Gun* soundtrack. That display is followed by the quieter but impressive aerobatics of the Breitling Jet Team, flying six Czechoslovakian L-39 Albatros cold war trainers.

Belying the fighter pilot stereotype, the jet pilots at the show openly admire their elders and their airplanes. The 36-year-old Mirage 2000 pilot, a captain in the French air force, says that when he retires, he hopes to buy an old airplane and fly it around at shows like the guys at La Ferté Alais.

Despite the undercurrents of purism, the show has a spirit of openness and curiosity about the aircraft of other eras, other nations. Chabbert, the announcer, gets in a dig at what he perceives is a more narrow-minded aviation culture, commenting: "The Americans don't always honor the beauty of airplanes other than their own." Is he right, or just being French? Here at Cerny, the hope is that one day more Blériots and SPADs will fly at airshows in the States—or at least putter happily along the airfields there.

CAROLINE SHEEN


XAVIER MEAL

JUMP in a LAKE

BY DAN FORD | PHOTOGRAPHS BY GILLES AULIARD

WHY FLOATPLANES FLOCK TO MOOSEHEAD.

When I awake in my room in Chalet Moosehead in Greenville, Maine, I find a Piper PA-12 floatplane tied to the beach beneath my window. I'm daffy about Cub-type airplanes, and one of the perks of attending the 32nd International Seaplane Fly-in is to look out every morning upon Three Yankee Foxtrot, a tube-and-fabric design introduced by William Piper in 1947. The owner evidently wants no part of the bomb drop, takeoff, landing, and canoe competitions that provide the fly-in's adrenaline rush, because 3YF never leaves its tie-down the entire weekend.

Indeed, you'd want the nerve of Sky King himself to join the Greenville traffic pattern this Saturday morning in September, as

An amphibious canine dives right in at the 2005 International Seaplane Fly-in at Maine's Moosehead Lake, where a Russian Beriev Be-103 stole the show (opposite).

the fly-in moves into high gear. There are about a hundred floatplanes at the state Fish and Game Department seaplane base, on the east side of 32-mile-long Moosehead Lake, in the heart of Maine's Northwoods. A Cessna 180 takes off to the north, engine screaming, floats spraying water. An ultralight drones overhead on a bombing run (the bomb is a grapefruit: Each contestant gets two, with the one splashing closest to the red buoys scoring). A Husky pilot announces on the radio that he's entering the pattern from the west—"At your discretion," replies the traffic coordinator—and, as a flourish, 14 Canada geese plop down in the cove with a flurry of wings.

An amphibian floatplane is powering toward the Fish and Game ramp, where 30 youngsters in Civil Air Patrol uniforms are moving aircraft around and keeping spectators away from spinning propellers. "November Lima," says the radio to the trespasser, "better turn right. There's a plane about to come down that ramp."

Three ultralights have flown the 200 miles from New Hampshire's Lake Winnipesaukee, refueling once at a marina along the way. "We could have made it with half a gallon to spare," boasts Kit Clews of Portsmouth, here for his seventh Moosehead fly-in. The ultralights have proved formidable competitors in the takeoff category. "They got tired of us taking off in 27 feet," Clews says. "So now they've given us a class of our own."

His craft is an Air Creation, a homebuilt with a pusher propeller and floats that seem bigger than its parasol wing. Another Air Creation casts off from shore with its engine silent, to be caught by the wind and driven onto a Cessna tied at the float; the pilot jumps out, dances on the float to a smatter of applause, and tilts the wing so it neatly clears the Cessna's. The Rotax engine is a pull-start, like a lawnmower. It doesn't start, and eventually the Air Creation vanishes around the corner, heading for town at a good two or three knots on wind power alone.

Roger Currier (left), the go-to guy for local air tours, started with a beat-up Cessna 180 and now offers rides in vintage floatplanes for leaf-peeping and moose-spotting (below). A 1965 Cessna 180H at the fly-in lumbers over Greenville's picture-postcard East Cove (right).

The International Seaplane Fly-In dates to 1973. Greenville also has a landplane base, which started as an 1,800-foot grass strip on the high ground east of town, where the Walden family raised potatoes and swapped them for necessities. "My sister Deborah had radar for ears," 83-year-old Ed Walden recalls. "She'd shout 'Airplane!' before any of the rest of us heard the engine, and we'd run outside and spread sheets on the grass as a sign to the barnstormer that he could come down." In addition to the excitement his visit generated, a barnstormer might pay a dollar or two for dinner and a bunk for the night.

Also toward the end of the Depression, Maine's Senator Owen Brewster decided that "if airplanes are going to go anywhere in the future, they've got to have someplace to set down," says Walden. That led to the Civil Aeronautics Act and a big federal hand in building airports, including $83,000 to acquire and expand the Greenville airstrip. "Son," wrote Harold Walden to Ed, then a student at the University of Maine, "they're going through with the airport. If you want the farm, you'd better come home." The Waldens cut the house in half with a handsaw, dismantled the barn to use the timbers for skids, borrowed a tractor from the airport construction crew, and dragged the house a few miles down the road. (Ed's grandson lives there now.)

In the realm of general aviation, airplanes with wheels outnumber those with floats, a statistic reflected at the fly-in. There are twice as many landplanes and amphibians parked at the airport—233—as there are floatplanes in the cove. Walking the flightline on Saturday evening, I find airplanes parked wingtip to wingtip along both sides of the approach end of Runway 21. Some pilots sleep in tents beneath the wings; others have set up more elaborate accommodations in the grass behind their aircraft. The air is rich with the smell of barbecued beef, and the yelps of children and dogs.

Roger Currier owns Currier's Flying Service, which offers air tours in vintage floatplanes; he came to Greenville in 1982 on the offer of a job from Dick Folsom, whose name for half a century was

All manner of aircraft are welcome at the fly-in, including an Air Creation amphibian ultralight (above). The event draws both fliers and non-fliers to the Moosehead shoreline (below).

synonymous with bush flying in the wilds of Maine. By that time, the paper companies that own most of the wilderness had learned that it was cheaper to build roads than float the logs downriver to the mill. The roads are open to the public, and they quickly found favor with hunters, fishermen, snowmobilers, and folks who live in the backcountry, causing a drop in business for the bush pilots.

When Currier arrived, he found that Dick Folsom no longer needed another pilot. Currier instead worked for Jack Hofbauer, a Delta Air Lines pilot who ran a seaplane service on the side. "He was in and out," Currier recalls in a soft voice, "and the rest of his family ran the business. One of my bosses was a 13-year-old girl. So I decided to do my own thing."

The state of Maine sold him a beat-up Cessna 180 with 3,000 hours on the airframe. Over the next 23 years, he added another 7,000. "It's been a good plane," he says with considerable understatement. Meanwhile, he added two burly Cessna 195s, another 180, and a de Havilland Beaver. (The Curriers also own a 1952 Jeep and a pair of Volkswagen Beetles.)

At the same time, a new generation of bureaucrats was replacing the old-timers at the Federal Aviation Administration regional office, and they took notice of the fact that what the bush pilots were doing was, well, not according to regulations. Most floatplanes are certified to carry canoes only when flying "restricted"—and as the pilot of a restricted aircraft, you can't take passengers for a fee. Strictly speaking, what a bush pilot must do is fly the canoe without charge, then make another flight in the "general" category with the paying passengers.

"Pretty darned expensive," Roger Currier points out, "and not cost-effective when we could be doing back-to-back sightseeing tours all day." (That the FAA got exercised about a little thing like carrying a canoe on a float is amusing,

considering that Greenville's archetypal bush pilot, Charlie Coe, was forever inventing uses for his airplane: In the summer he towed water skiers with it, and in the winter he moved logs across the ice.)

Seaplanes had their heyday in the 1930s and 1940s, when U.S. designers created the Republic Seabee and Grumman Goose. There were five Seabees on the Fish and Game ramp Saturday morning. There are a few modern airplanes here too, notably a twin-engine, low-wing, six-place Russian amphibian, a Beriev Be-103 that catches everyone's eye—especially when it takes off, spewing water halfway out to the wingtips. And there are a smattering of foreign pilots, enough to justify the "international" in the event's name. Andre Durocher flew down from Ottawa in a 600-horsepower de Havilland Beaver floatplane that he bought a few years ago, supposedly as an investment; he and his passenger wear T-shirts with a portrait of the Beaver front and back, and the legend: "For Sale." But he's in no hurry to close a deal. He showed off the airplane at the Oshkosh, Wisconsin mega-fly-in last July, and now he's geared up for the Moosehead Lake bomb drop.

The fly-in also attracts pilots who have left their wings at home—like me. "You gotta fly to these things," protests Don LaCouture Jr. of Marlboro, Massachusetts, when I admit that my transportation is a Honda Accord. Against a headwind, he needed three and a half hours to fly up in his father's PA-18 Super Cub. On reflection, he amends his view: "Well, at least you know you're gonna get home!"

Jack Sellett has a better excuse for driving. He came from Florida with his wife and dog in a motor home, using the fly-in as the far point of a grand tour of aeronautical landmarks. They visited Old Rhinebeck Aerodrome in New York on the way north, and they'll visit the National Air and Space Museum in Washington when southbound. Sellett carries photos of his former seaplanes in his wallet and displays them at every opportunity. He also tells war stories nonstop: "I landed in Everglades National Park and the ranger said to me, 'You know you're not supposed to land here, but you were having spark plug problems, weren't you?' "

On the flightline, there's instant camaraderie, with people comparing

Folsom's Air Service, created in 1946 by local legend Dick Folsom, was inherited 40 years later by son Max, one of the founding fathers of the fly-in. Below: A Super Cub, even more super on floats, also makes a handy clothesline. Opposite: Produced in the 1940s, the Republic Seabee is a classic flying boat; here, one achieves splashdown at Moosehead. Opposite, below: A Civil Air Patrol squadron hauls a Cessna 206F ashore at the state Fish and Game Department ramp.

stories, dogs, and airplanes. "I had a 205 like that," Sellett muses about a green Cessna tied down nearby. "It had a control cable failure, and I had to put it down in a hurry. The dog and the three of us walked away." Turns out that the owner of the green Cessna had a like experience, except that he was fortunate enough to be over an airport when it happened.

There's also a bunch of pilots from Spencer, Massachusetts, who turn up in Greenville every year without taking part in the fly-in, except as spectators. After work on Friday, Steve Foley loaded his 14-year-old son and a quarter-keg of beer into his Cessna 150 and flew north, reaching Greenville just as the sun was setting. "You can see the lights in Greenville from a good ways off," Foley says. This was a relief to one of his friends, who set out one year in a Piper J-3 with no electrical equipment (and who therefore remains nameless): "He was going too slow and ended up flying at night with no lights. He would light a match every 15 minutes or so and check his heading on the compass."

Gregg Andrews, who owns the Spencer airport, bought a small vacation house in Greenville, mostly for the sake of the fly-in. "It's a pretty neat thing to see them all together, all the old Grummans and such," he says. So now the Spencer airport gang, 30-strong, camp at Andrews' place. On Saturday night, they put on their own communal barbeque: "Twenty pounds of roast beast cooked over an open fire," as Steve Foley describes it, "with a spit made from a hangar door gear drive transmission and an electric motor."

The 33rd International Seaplane Fly-In is scheduled for September 7 through 10, 2006. If you too leave your wings at home, Currier's Flying Service will take you flightseeing for as little as $70 for two. And remember, as the Black Frog restaurant menu warns, "When dining in Maine, never assume it's a raisin."

SEE IT ALL

AIRSHOWS 2006

ALABAMA

Birmingham **Sept. 23 & 24**
Wings & Wheels

Maxwell AFB **Apr. 8**
Maxwell AFB River Region Air Show (Thunderbirds)

ALASKA

Elmendorf AFB **Aug. 12 & 13**
Arctic Thunder (Blue Angels)

ARIZONA

Goodyear **Oct. 28 & 29**
Thunderbird Balloon and Air Classic

Prescott **Sept. 30**
Arizona Skyfest

ARKANSAS

Fayetteville **June 17 & 18**
Arkansas Air Museum Airfest

Fort Smith **Mar. 25 & 26**
Fort Smith Regional Air Show (Thunderbirds)

Little Rock AFB **Oct. 28 & 29**
Little Rock AFB Open House

CALIFORNIA

Beale AFB **June 3 & 4**
Beale AFB Air Show (Thunderbirds)

Edwards AFB **Oct. 28 & 29**
Edwards AFB Open House (Thunderbirds)

Fairfield **Oct. 14 & 15**
Travis AFB Air Expo

Fresno **June 17**
KJWL Father's Day Air Show & Fly-In

Los Angeles **June 24**
American Heroes Air Show

March ARB **Apr. 29 & 30**
March ARB Air Show (Thunderbirds)

DELAWARE

Dover **May 13 & 14**
Dover Air Force Base Open House

FLORIDA

Ft. Lauderdale **May 6 & 7**
Ft. Lauderdale Air & Sea Show (Blue Angels, Snowbirds)

Ft. Myers **May 20 & 21**
Ft. Myers Beach Air Show

Lake City **Nov. 11 & 12**
North Florida Air Show

Lakeland **Apr. 4–10**
Sun 'n' Fun (Snowbirds)

NAS Jacksonville **Oct. 28 & 29**
NAS Jacksonville Air Show

NAS Pensacola **Nov. 4 & 5**
Blue Angels Homecoming

Pensacola Beach **July 15**
Pensacola Beach Air Show (Blue Angels)

Punta Gorda **Apr. 1 & 2**
Florida International Air Show (Thunderbirds)

St. Augustine **May 6 & 7**
Air Show St. Augustine

St. Petersburg **Oct. 7 & 8**
Suncoast Airfest

Stuart **Nov. 12 & 13**
Stuart Air Show

Tyndall AFB **Apr. 22 & 23**
Tyndall AFB Gulf Coast Salute (Thunderbirds)

GEORGIA

Atlanta **May 6**
American Heroes Air Show

Eastman **June 10**
Georgia State Air Show

Kennesaw **Oct. 7 & 8**
Transportation Expo

NAS Atlanta **Apr. 29 & 30**
NAS Atlanta Air Show (Blue Angels)

Gary **Sept. 3 & 4**
Gary Air Show (Thunderbirds)

Goshen **July 1**
Freedom Fest

Greenfield **Aug. 26 & 27**
Indianapolis Air Show (Thunderbirds)

Muncie **June 17 & 18**
Summer Heat Air Festival

Terre Haute **Sept. 16 & 17**
Terre Haute Air Fair

IOWA

Burlington **Sept. 16**
Burlington Regional Air Show

Davenport **June 3 & 4**
Quad City Air Show (Blue Angels)

KANSAS

McConnell AFB **Sept. 9 & 10**
AVN Festival (Thunderbirds)

Wichita **Aug. 26 & 27**
Wichita Aviation Festival

KENTUCKY

Louisville **Apr. 22 & 23**
Thunder Over Louisville (Blue Angels)

LOUISIANA

Barksdale AFB **May 13 & 14**
Defenders of Liberty Air Show

Belle Chasse **Oct. 21 & 22**
NAS JRB N'awlins Air Show

MAINE

Portland **Sept. 23 & 24**
Aviation Past & Present

MARYLAND

Andrews AFB **May 20 & 21**
DoD Joint Services Open House (Blue Angels)

MASSACHUSETTS

Nantucket **Sept. 30 & Oct. 1**
Nantucket Air Show (Blue Angels)

MISSOURI

Cape Girardeau **July 8 & 9**
Cape Girardeau Regional Air Festival

Chesterfield **Sept. 1–4**
St. Louis County Fair & Air Show

Columbia **May 28 & 29**
Salute to Veterans Celebration

Kansas City **Sept. 16 & 17**
KC Aviation Expo (Blue Angels)

Mexico **Aug. 19**
Mexico Air Show

Poplar Bluff **May 13**
Poplar Bluff Air Show

St. Joseph **July 8 & 9**
139th Air Wing Missouri ANG 60th Anniversary Air Show

Whiteman AFB **June 17 & 18**
Wings Over Whiteman

NEBRASKA

Lincoln **Sept. 23 & 24**
Guardians of Freedom Air Show (Blue Angels)

NEVADA

Nellis AFB **Nov. 11 & 12**
Aviation Nation (Thunderbirds)

Reno **Sept. 13–17**
National Championship Air Races (Thunderbirds)

NEW JERSEY

Atlantic City **Aug. 23**
Thunder Over the Boardwalk (Thunderbirds)

Camden **Aug. 5**
Battleship *New Jersey* Aviation Awareness Day

Millville **June 24 & 25**
Wings & Wheels Air & Car Show

NEW MEXICO

Cannon AFB **May 27**
Air Power Expo (Thunderbirds)

NORTH DAKOTA

Grand Forks **July 22**
Friends and Neighbors Day (Thunderbirds)

Minot AFB **July 7 & 8**
Northern Neighbors Day (Snowbirds)

OHIO

Akron **June 17 & 18**
Aero Expo: Defenders of Freedom

Akron **Sept. 10**
National Radial Engine Exhibition

Cincinnati **Sept. 16 & 17**
Blue Ash Airport Days

Cleveland **Sept. 2–4**
Cleveland National Air Show (Blue Angels)

Dayton **July 29 & 30**
Vectren Dayton Air Show (Blue Angels)

Willoughby **July 14–16**
Gathering of Eagles XI

OKLAHOMA

Altus AFB **May 20**
Altus AFB Air Show (Thunderbirds)

Vance AFB **May 20**
Vance AFB Air Show

OREGON

Hillsboro **July 15 & 16**
Oregon International Air Show

Madras **Aug. 26**
Central Oregon Air Show

PENNSYLVANIA

Lancaster **Aug. 26 & 27**
Lancaster Airport Community Days Air Show

NAS JRB Willow Grove **June 17 & 18**
NAS JRB Willow Grove Air Show (Thunderbirds)

TENNESSEE

Tullahoma **May 27 & 28**
55th Anniversary of AEDC Air Show

TEXAS

Burnet **Apr. 8**
CAF Bluebonnet Air Show

Dyess AFB **May 21**
Dyess AFB Open House (Thunderbirds)

El Paso **Oct. 7 & 8**
Amigo Airsho (Snowbirds)

Ft. Worth **Sept. 30 & Oct. 1**
Ft. Worth International Air Show (Thunderbirds)

Galveston **Apr. 29 & 30**
Lone Star Flight Museum Spirit of Flight

Galveston **Nov. 13**
Lone Star Flight Museum Fly-Day

Hondo **May 12–14**
EAA Southwest Regional Texas Fly-In

Houston **Oct. 21 & 22**
Wings Over Houston (Thunderbirds)

Lackland AFB **Nov. 4 & 5**
Lackland AFB Air Show (Thunderbirds)

Midland **Oct. 7 & 8**
FINA-CAF Airsho

NAS Ft. Worth **May 13 & 14**
NAS Ft. Worth Air Show (Blue Angels)

NAS Kingsville **Apr. 1 & 2**
NAS Kingsville Open House (Blue Angels)

Odessa **May 20**
American Heroes Air Show (Blue Angels)

Temple **May 6 & 7**
Central Texas Air Show

Pasco **July 29 & 30**
Tri-City Air Show & Water Follies

Seattle **June 10**
American Heroes Air Show

Seattle **Aug. 5 & 6**
Seafair (Blue Angels)

Tacoma **July 4**
Tacoma Freedom Fair Air Show

WISCONSIN

Janesville **June 10 & 11**
Southern Wisconsin Airfest

La Crosse **June 17 & 18**
Deke Slayton Airfest

Manitowoc **June 3 & 4**
Manitowoc Air Show

Milwaukee **July 8 & 9**
Greater Milwaukee Air & Water Show

Milwaukee **July 15 & 16**
TCF Bank Air Expo on Milwaukee's Lake Front (Thunderbirds)

Oshkosh **July 24–30**
EAA Airventure

WYOMING

Casper **July 22 & 23**
Wings Over Wyoming (Thunderbirds)

Cheyenne **July 26**
Cheyenne ANG Air Show (Thunderbirds)

CANADA

BC British Columbia
NF Newfoundland
NS Nova Scotia
ON Ontario
QC Quebec
SK Saskatchewan

Abbotsford, BC **Aug. 11–13**
Abbotsford International Air Show (Snowbirds)

Borden, ON **June 24 & 25**
Borden Air Show (Snowbirds)

Marysville June 9–11
Golden West EAA Regional Fly-In & Air Show

Mojave Oct. 4
Mojave Air Show (Snowbirds)

NAS Point Mugu Oct. 7 & 8
Point Mugu Air Show

Ramona June 24 & 25
Ramona Air Fair

Redding Sept. 30 & Oct. 1
Redding Air Show (Snowbirds)

Riverside Apr. 1
Riverside Air Show

Salinas Sept. 30 & Oct. 1
California International Air Show

San Carlos June 17 & 18
Vertical Challenge Helicopter Show

San Diego Oct. 13–15
MCAS Miramar Air Show

San Francisco Oct. 7 & 8
San Francisco Fleet Week

Santa Maria Aug. 26 & 27
Thunder Over the Valley Air Show

Santa Rosa Aug. 19 & 20
Wings Over Wine Country

Van Nuys June 11
VNY Rockin' Airfest

Watsonville May 26–28
Watsonville Fly-In & Air Show

COLORADO

Buckley AFB Aug. 6
Rocky Mountain Thunder

Denver June 10
Jeffco Airport Open House

Pueblo Aug. 12 & 13
In Their Honor Air Show

CONNECTICUT

Groton June 17 & 18
Groton Family Airfest

Peachtree City Oct. 14 & 15
The Great Georgia Air Show

Robins AFB May 13 & 14
Robins AFB Air Show (Thunderbirds)

Vidalia Apr. 29 & 30
Vidalia Onion Festival Air Show (Snowbirds)

HAWAII

Kaneohe Oct. 7 & 8
Blues on the Bay

IDAHO

Twin Falls June 23 & 24
Air Magic Valley

ILLINOIS

Chicago Aug. 19 & 20
City of Chicago Air & Water Show (Blue Angels)

Lake in the Hills June 17
Lake in the Hills Air Expo

Peoria July 22 & 23
Prairie Air Show

Peru June 17 & 18
Illinois Valley Air Show

Rockford Sept. 23 & 24
Rockford Air Show (Thunderbirds)

Scott AFB Aug. 12 & 13
Scott AFB Open House (Thunderbirds)

Springfield June 24 & 25
Springfield Air Rendezvous

INDIANA

Evansville June 24 & 25
Evansville Freedom Festival

Westfield June 24 & 25
Westfield International Air Show (Blue Angels)

MICHIGAN

Battle Creek July 2–4
Battle Creek Balloon Championships (Snowbirds, Thunderbirds)

Bay City Aug. 12 & 13
Bay City Air Show

Belleville Aug. 5 & 6
Thunder Over Michigan

Muskegon July 22 & 23
Muskegon Air Fair

Traverse City July 1 & 2
National Cherry Festival Air Show (Blue Angels)

MINNESOTA

Brainerd June 24 & 25
Brainerd Lakes Area Air Show

Duluth July 8 & 9
Duluth Air & Aviation Expo (Thunderbirds)

Red Wing May 27 & 28
Wings of Freedom—Salute to Veterans

MISSISSIPPI

Columbus AFB Apr. 8 & 9
Wings Over Columbus—Career Day (Thunderbirds)

Greenville Sept. 9
Delta Air & Balloon Festival

Tunica June 3 & 4
Tunica Air Races

Kirtland AFB July 1
Kirtland AFB Air Show (Thunderbirds)

NEW YORK

Binghamton July 1
Binghamton Air Show

Geneseo July 8 & 9
Geneseo Air Show

Wantagh Park May 27 & 28
New York Air Show at Jones Beach (Blue Angels)

NORTH CAROLINA

Andrews-Murphy Oct. 21
Celebration of Flight

Fayetteville May 10
Pope AFB-Ft. Bragg Open House (Snowbirds)

MCAS New River May 13 & 14
MCAS New River Air Show (Snowbirds)

Seymour Johnson AFB Nov. 5 & 6
Wings Over Wayne County Air Show (Thunderbirds)

Pittsburgh July 8 & 9
Wings Over Pittsburgh (Blue Angels)

Reading June 2–4
World War II Weekend

West Chester Oct. 14 & 15
Rotorfest All Helicopter Air Show

RHODE ISLAND

North Kingstown June 24 & 25
Rhode Island ANG Open House (Thunderbirds)

SOUTH CAROLINA

Charleston AFB Apr. 8
Charleston AFB Air Expo (Blue Angels)

Florence May 6 & 7
May Fly Air Show

SOUTH DAKOTA

Sioux Falls July 22 & 23
Sioux Falls Air Show (Blue Angels)

UTAH

Hill AFB June 10 & 11
Hill AFB Air Show (Thunderbirds)

Provo July 1 & 2
Heber Valley Air Show

Wendover Aug. 26
Wendover Airfield Air Show

VERMONT

Colchester Aug. 19
Vermont ANG 60th Anniversary Open House (Thunderbirds)

VIRGINIA

Danville June 3 & 4
Southside SkyFest

Langley AFB May 6 & 7
AirPower Over Hampton Roads (Thunderbirds)

Virginia Beach Sept. 9 & 10
NAS Oceana Air Show (Blue Angels)

WASHINGTON

Fairchild AFB July 29 & 30
Fairchild AFB SkyFest (Thunderbirds)

Gander, NF Sept. 13
Newfoundland Air Show

Halifax, NS Sept. 9 & 10
Nova Scotia International Air Show (Snowbirds)

Moose Jaw, SK July 8 & 9
Saskatchewan Air Show (Snowbirds)

Niagara-on-the-Lake, ON Aug. 26 & 27
Wings & Wheels Niagara (Snowbirds)

North Bay, ON May 20–22
North Bay Heritage Festival & Air Show (Snowbirds)

Oshawa, ON June 23–25
Canadian Aviation Expo (Snowbirds)

Ottawa, ON June 17 & 18
Air Show Ottawa (Snowbirds)

Quebec, QC June 10 & 11
Quebec Air Show (Blue Angels, Snowbirds)

Sarnia, ON Sept. 23 & 24
Sarnia International Air Show

2006 AIRSHOW SCHEDULE

SCHEDULE INFORMATION provided by the Department of Defense and the International Council of Air Shows (**www.airshows.org**, phone 703-779-8510) as of February 2006. Subject to cancellation or change of city, date, name, and performers. Check local listings.

AFB	Air Force Base
ANGB	Air National Guard Base
ARB	Air Reserve Base
EAA	Experimental Aircraft Association
JRB	Joint Reserve Base
MCAS	Marine Corps Air Station
NAF	Naval Air Facility
NAS	Naval Air Station
USAF	United States Air Force

MIKE ULLERY (2)

TORTURE

The Air Force's McKinley lab blows hot and cold. ~by Ed Regis

ON A 95-DEGREE mid-September day in the Florida panhandle, a Raytheon Hawker Horizon business jet taxied up to a hangar at Eglin Air Force Base, a joint-use facility whose civilian side is the Okaloosa Regional Airport. The "Hawk," as it is called at Raytheon, is a glossy new eight-passenger bizjet to which the Federal Aviation Administration granted a provisional type certificate in December 2004. However, a bit of additional testing was necessary to gain final FAA approval, so the aircraft was towed inside the hangar, where technicians hooked up its two Pratt & Whitney turbofan engines to a pair of exhaust ducts, ran instrumentation cables to a sound-protected, temperature- and humidity-controlled observation booth, and chained the aircraft to a set of anchors embedded in the concrete floor.

The next morning it was –40 degrees inside the hangar, which had been sealed against the outside. The Raytheon test crew entered the aircraft, started the Hawk's engines, and, after a short countdown, slammed them to full power. The engines boomed for about an hour at various power settings as the hot exhaust streamed through ductwork and out the rear of the hangar; nevertheless, the indoor temperature remained a steady and crisp –40. By rights, two jet engines running at high speed inside a closed space should have created a vacuum that would have collapsed the hangar and drawn the debris through the engine intakes. The reason that didn't happen is just one of the technological mar-

CHAMBER

vels of the McKinley Climatic Laboratory, the world's largest torture chamber for aircraft in search of FAA or military certification.

The McKinley lab can create just about every weather condition imaginable, and some that are unimaginable. "We can make it rain up to 25 inches per hour," says lab director Kirk Velasco. Using the type of snow machines found on ski slopes, lab workers can produce whiteout blizzards in the chamber. They can create fog, wind, and icing, generating a layer of "unlimited ice thickness" over your entire aircraft (along with icicles that hang from the ceiling, some weighing 200 pounds), then follow such a display with a scorching burst of simulated solar radiation. They can vary the relative humidity between 10 percent and 100 percent. Moreover, they can do this for aircraft of any size, including a Boeing B-29, a Northrop B-2, a Lockheed C-5A, a Lockheed Martin F-22, a Boeing 747, general aviation airplanes, and helicopters, all of which have been run at full power (and the helicopters at full collective) through McKinley's weather gantlet. The only airplane too big to pass between

Extreme weather reigns at the McKinley Climatic Laboratory in Florida, which has chilled, grilled, and steamed every aircraft in the current U.S. military inventory, including Lockheed's C-130, here undergoing a cold test in the cavernous main chamber.

ALL PHOTOGRAPHS COURTESY U.S. AIR FORCE EXCEPT WHERE NOTED

THE SALT FOG CHAMBER CAN PRODUCE AN OVEN-LIKE 149 DEGREES AND A JUNGLE-LIKE 100 PERCENT HUMIDITY, TOGETHER WITH A CORROSIVE FOG SOLUTION CONSISTING OF FIVE PERCENT SODIUM CHLORIDE IN WATER. THE SUN, WIND, RAIN, AND DUST CHAMBER CAN BLAST VARIOUS COMMERCIALLY AVAILABLE GRADES OF SAND AT A TEST ITEM FOR HOURS AT A TIME.

McKinley also tests products for the civilian market, including a Cessna bizjet (left) and snow tires on a minivan (above).

the lab's dual 15-inch-thick, stainless steel, 200-ton hangar doors is the forthcoming Airbus A380 airliner, whose wingspan is about 10 feet too long. "They'll have to chase the weather," says Velasco of the Airbus testers. "We're not the only game in town: Mother Nature also provides. You can chase icing clouds to find icing conditions. It just takes a lot more time, and you do a lot of flying around."

Over its nearly 60 years, the McKinley lab has tested every military aircraft in the current U.S. inventory, plus many civilian craft, not to mention a gaggle of missiles, bombs, Humvees, tanks, trucks, howitzers, ground-support equipment, hard- and soft-walled shelters, and even cars and snow tires, among other things. For smaller items and more specialized climatic cruelties, the McKinley lab has five test cells in addition to the cavernous Main Chamber. The Salt Fog Chamber can produce an oven-like 149 degrees and a jungle-like 100 percent humidity, together with a corrosive fog solution consisting of five percent sodium chloride in water. The Sun, Wind, Rain, and Dust Chamber can blast various commercially available grades of sand at a test item for hours at a time.

Recently, Velasco and his group subjected a 25-mm Gatling gun from a Lockheed AC-130U "Spooky" gunship to conditions perhaps encountered regularly in the Gobi desert. "We did a major sand test," he says. "I mean we beat the crap out of it with sand—40-mile-an-hour windblown sand—for six hours." Afterward, when lab workers aimed the Gatling gun at an in-house bullet catcher and fired, the weapon still worked.

Concern about the effect of cold weather on aircraft led the U.S. Army Air Corps to establish the Cold Weather Detachment at Ladd Field, Alaska, in 1940, and place it under the command of Lieutenant Colonel Ashley C. McKinley, a former dirigible pilot who had photographed American explorer Richard Byrd's expedition to the Antarctic in 1928 and '29. After a short stint at Ladd, however, McKinley realized that instead of flying each prototype aircraft to Alaska and back, it would make more sense, and cost the military much less, to create weather on demand, mechanically, at a geographic point that was easy to get to. McKinley also thought it reasonable that all U.S. combat aircraft be required to operate at –65 degrees.

In 1943, the U.S. Army Air Forces directed that an immense climate-controlled hangar be built at Eglin Field in Florida. Four years later, in May 1947, the Eglin Climatic Hangar was in operation, and within 50 years it had run its heavy weather conditions across more than 300 aircraft and 2,000 pieces of equipment. Between 1994 and 1997, the facility underwent a ground-up renovation, which created the lab that is in place today.

Although the principles of refrigeration are comparatively simple and relatively ancient (the first U.S. patent for mechanical refrigeration was granted in 1851), the scale and complexity of the cooling system at McKinley boggle the mind. The Main Chamber has two basic refrigeration modes

The lab simulates rain in all forms: The freezing variety coats a Lockheed Martin F-117 (below), and wind-blown rain sprays the company's F-22 Raptor in a test to see if water pools in weapons bays and other openings.

(plus a heating mode), the first for cold-soaking the aircraft when its engines aren't running. The setup here is a closed-loop system, the same in principle as that found in a home refrigerator or window air conditioner: Cool a refrigerant, send it through a set of coils, and then blow air over the coils. Doing this on the vast proportions of McKinley's three-million-plus cubic feet of airspace is a simple matter of scaling up all the components: gigantic, screaming compressor pumps, huge squirrel-cage fans, monster cooling coils, and massive jolts of power. (McKinley has its own electrical substation so that when the system starts running, lights don't dim in the surrounding community. As it is, the lab's electric bill averages between $100,000 and $200,000 a month.)

During closed-loop operation, fans withdraw ambient air from inside the chamber, blow it over the cooling coils, and send the cold air up into ceiling ducts that distribute it through large circular diffusers. The same air is recycled through the system again and again, reducing the chamber's temperature incrementally with each pass. (For high-temp tests, steam is run through the coils.)

The situation changes, however, when an aircraft's jet engine is running, something that cannot happen in a closed system due to the process of combustion, which sucks in copious amounts of hangar air and forces it out through the engine exhaust system. All that air must be replaced at the precise rate at which it is being consumed. Plus, with the engines and exhaust ductwork radiating heat into the hangar, the incoming air must be cold enough to maintain the target temperature. Keeping up with all that heating and venting requires a whole new dimension in cooling and airflow management, which at McKinley is a masterpiece of engineering called the air makeup system.

"The air makeup system will take that outside air at 95 degrees, cool it down to –40 degrees, and dump it into the chamber at the exact same rate that the engines are using it," says Velasco. The system has two primary components, the first of which is the air makeup building proper, which is a separate, free-standing, two-story structure housing an air-intake duct, one steam coil and two successive ranks of air conditioning coils, and an exhaust duct that pours a continuous volume of fresh-frozen air into the Main Chamber through a large square hole in the ceiling.

However, there is no way that even McKinley's powerful compressors can produce the mass of cold air needed to balance a 747's four engines running at cruise power for a

COURTESY LOCKHEED MARTIN

solid hour. The solution: Chill a whole lot of coolant in advance and store it at low temperature until it's needed. Accordingly, for two days prior to the Raytheon Hawker Horizon test, McKinley's air makeup team has been cooling down the facility's most potent refrigerant, R30, a.k.a. methylene chloride, to a temperature of –100 degrees, then shunting it into a 750,000-gallon cylindrical tank adjacent to the air makeup building. Big as a house, that tank of liquid frigidity is really the crux of the entire enterprise.

"This system can take outside air as hot as 105 degrees Fahrenheit and cool it down to minus 80 degrees Fahrenheit, at a rate of 1,000 pounds mass of air per second," says Velasco. "So as long as your engines aren't using more than a thousand pounds mass per second of air, we can maintain the conditions in there while those engines are operating."

Lab personnel are kept informed of equipment functioning by the Facility Monitoring and Control System, a room that runs 24/7 to keep tabs on the facility's hundreds of valves, miles of piping and electrical circuitry, and compressor pumps, steam boilers, heat exchangers, evaporators, condensers, nozzles, ducts, fans, backflow dampers, plenum doors, cooling towers, surge tanks, storage tanks, coil banks, pressure vessels, and large-scale fluid flows. A day's use of the Main Chamber can cost between $10,000 to $25,000. If all you're doing is a simple snow-load test of a tent, figure the lower end. "If you have something really complex," says Velasco, "like a military Joint Strike Fighter, the F-35, the short-takeoff-and-landing version—it's got a big lifting fan in the middle, it's got variable exhaust in the back, a very complicated exhaust setup that we have to specially design and build—that gets up to $25,000 a day."

Velasco, a thin, balding aeronautical engineer in his late 40s, came to Eglin in 1984 after spending three years doing climatic testing at Edwards Air Force Base in California's Mojave Desert. One of the tests involved bringing a Lockheed F-16 to McKinley for the full treatment. The place impressed him so much that he transferred to Eglin and never left.

In the years since, Velasco has seen it all, but the tradition at McKinley is to maintain a strict code of *omerta* about test results. After all, any aircraft, military or civilian, is manufactured by a company whose board members would rather that the outside world not know that during one of the lab's –40-degree tests, its precious airplane's landing gear wouldn't retract or, worse, extend.

"I hate to talk about stuff like that," Velasco admits. Nevertheless: "I remember vividly—and I won't mention the name of the aircraft—but we had a large aircraft in here and we did a rain test on it, and we filled it up with water. I mean, water was draining out of that aircraft for two days after we shut down. We could open panels and there were wing cavities filled with it. It was like a swimming pool, you could jump in and swim in it. It was leaking in because of the way they built the access panels—they were not sealed properly.

Snow machines pile powder on a Boeing B-52 Stratofortress.

"WE HAD A LARGE AIRCRAFT IN HERE AND WE DID A RAIN TEST ON IT, AND WE FILLED IT UP WITH WATER. I MEAN, WATER WAS DRAINING OUT OF THAT AIRCRAFT FOR TWO DAYS AFTER WE SHUT DOWN. WE COULD OPEN PANELS AND THERE WERE WING CAVITIES FILLED WITH IT. IT WAS LIKE A SWIMMING POOL, YOU COULD JUMP IN AND SWIM IN IT."

Like a whale in a tanning salon, a Lockheed C-5 Galaxy bakes under a bank of heat lamps in the main chamber, which was enlarged in 1968 to accommodate the Air Force's biggest cargo airplane (left). Above: Prior to an engine test of a Sikorsky S-92, the helicopter is tied down and its engine exhaust is ducted to the outside.

"Believe it or not, rain is a tough test to pass," Velasco adds. "We create a windblown rain, we don't just rain overhead and sprinkle on the thing. We have big wind machines blowing 50-mph winds, and you can blow it up under the wings and from all angles. You blow water everywhere."

Then, because it's ancient history, he talks about a B-52 test of a much-touted hydraulic fluid that wasn't supposed to catch on fire the way conventional fluids did when the bomber's hydraulic lines got hit by ground fire in Vietnam. "This B-52 had a rotating launcher inside of it that carried cruise missiles," says Velasco. "The thing's got to rotate and drop a bomb, rotate and drop a bomb, at minus 65 degrees. We were trying a newfangled type of hydraulic system—that was the whole test. The fluid was less flammable, but at the same time it was much more viscous. It was like molasses at minus 65 versus the old stuff, which would flow relatively freely at minus 65." So much for the new hydraulic fluid, which the Air Force summarily discarded.

The alternative response to the discovery of a defect is to modify the system at fault. "You'll have landing gear that won't come up because they made the hydraulic lines too small, so they have to go back and mod the lines, make a bigger hydraulic line," says Velasco. "They might have an eighth-inch line down to the gear and it's just too small, not enough fluid getting there fast enough, so they have to put in a quarter-inch line or a three-eighth-inch line."

At the other end of the temperature spectrum, heat poses a problem for avionics systems, especially those based on cathode-ray-tube displays, which generate lots of heat, compared to conventional gauges, which don't. An avionics meltdown, when it happens, prompts the company in question to beef up its "environmental control systems" (air conditioning).

After five days in the deep freeze, the Raytheon Hawker Horizon was covered by a light layer of frost. This was not another sign of lab-induced weather trauma but rather the result of technicians (most of them clad in parkas) repeatedly entering and exiting the hangar, letting in minute amounts of Florida humidity.

During a previous cold test at McKinley, the Hawk had been raised up on jacks so that its gear could be cycled, something that was done without difficulty. On this occasion, with an FAA representative in attendance to verify the results, the flight crew performed a series of low-temperature starts of the auxiliary power unit's battery, tested oxygen mask operation and the crew alerting system, monitored normal and emergency exit door forces, and so on. All challenges were met successfully. You might say that the whole thing was anticlimactic.

"There's lots of experience to draw upon," says Velasco, "and so the newer stuff is a lot better than it used to be in the old, old days."

When the Hawker Horizon is finally certified and takes to the skies, passengers, crew, and the general public can take comfort in the fact that it passed without a hitch through Kirk Velasco's little shop of weather horrors.

How Things Work:

Shuttle Tiles

by Damond Benningfield | Illustration by John MacNeill

In 1981, development of insulating tiles contributed to delays in the first shuttle launch, and last year, the difficulty of repairing tiles raised the world's anxiety about the shuttle's most recent mission. Though both flights ultimately went smoothly, the tiles have become the shuttle's most famous components.

Each shuttle is covered by more than 24,000 of the six- by six-inch blocks. Most of the tiles are made of silica fibers, which are produced from high-grade sand. Silica is an excellent insulator because it transports heat slowly. When the outer portion of a tile gets hot, the heat takes a long time to work its way down through the rest of the tile to the shuttle's skin. The tiles keep the orbiter's aluminum skin at 350 degrees or less.

The silica fibers are mixed with water and chemicals, and the mixture is poured into molds, which are zapped in microwave ovens at 2,350 degrees to fuse the silica fibers.

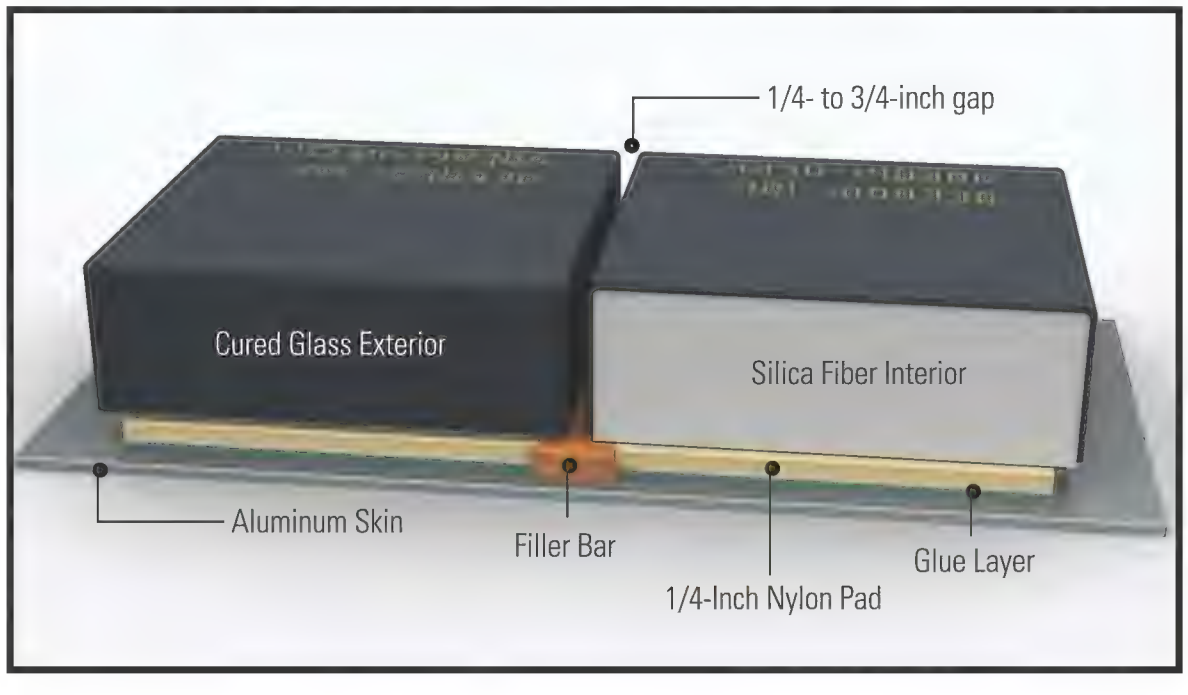
Tiles are too brittle to attach to the orbiter directly. The shuttle's skin contracts slightly while in orbit, then expands during reentry. In addition, the stresses of launch and reentry cause the skin to flex and bend. Such motions could easily crack the tiles or shake them off. To keep them in place, workers glue the tiles to flexible felt-like pads, then glue the pads to the orbiter.

The primary tiles used are given one of two coatings. The tiles exposed to reentry temperatures of up to 2,300 degrees Fahrenheit, such as those on portions of the belly, are given a protective coating of black glass. Black tiles work by reflecting about 90 percent of the heat they're exposed to back into the atmosphere, while the tiles' interior absorbs the rest. The tiles' interiors radiate absorbed heat so slowly that after landing, the tiles take hours to cool.

On parts of the shuttle's upper fuselage, which are exposed to much lower temperatures, the tiles are covered with a whitewash of silica compounds and aluminum oxide; these tiles protect against temperatures of up to 1,200 degrees.

NASA also uses two other types of tiles; denser and coated with stronger material, they provide extra protection to areas that are particularly vulnerable to strikes from space debris.

About 30 to 100 tiles are replaced before each mission. Some were lost or damaged during flight, while others were removed because workers needed to get to structures below them. When a new tile is needed, it is fabricated and installed at Florida's Kennedy Space Center. A computer-controlled machine cuts the tile to fit,



Tiles with black coatings can reflect most of the reentry heat they encounter back into the atmosphere. A flexible nylon pad beneath and intra-tile fillers reduce the shuttle skin's stress on the tiles.

either from stored patterns or from measurements of the actual space on the orbiter. In thickness, most tiles vary from about half an inch to four inches, depending on how much heat resistance is necessary. Because no two tiles are exactly the same size, "each one is custom-made," says Katherine Laufenberg, associate chief engineer for ground operations at United Space Alliance, the contractor that prepares the orbiters for flight. Installers leave small gaps between the tiles to prevent damage when the orbiter's aluminum skin moves. Sometimes, though, the gaps are too wide and are plugged with fillers.

Until recently, damaged tiles could be repaired only after the shuttle returned to Earth. That is about to change. Although the 2003 *Columbia* accident was caused by debris shed from a reinforced carbon-carbon panel on the wing's leading edge, the accident investigating board recommended, among other things, that NASA give the astronauts the capacity to perform "on orbit" repairs to the shuttle's exterior, including its tiles. The agency has developed two solutions.

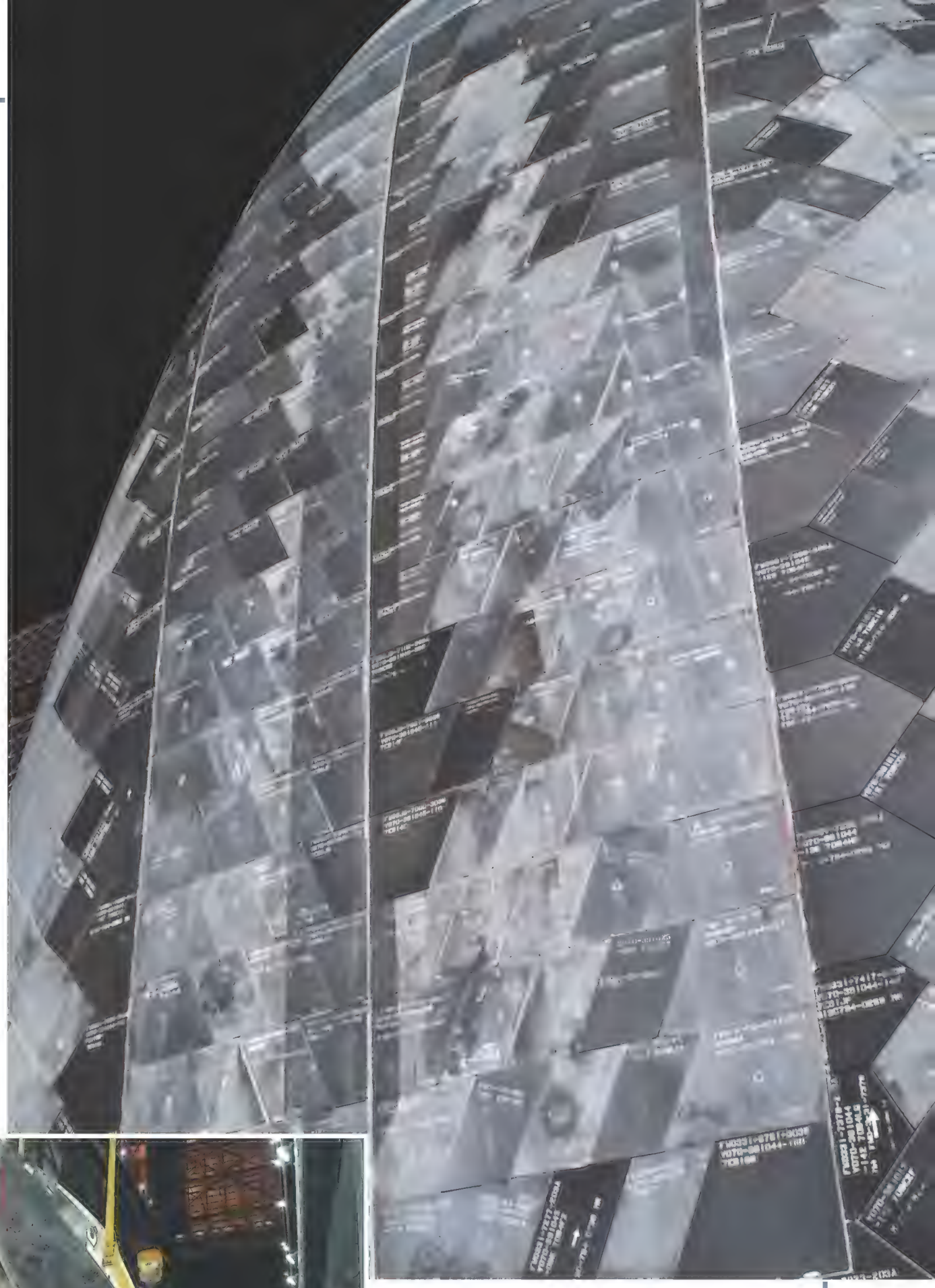
The first is called an emittance wash—a material that looks like shoe polish and consists of silicon carbide fibers mixed with the glue that bonds the tiles to the orbiter. Ground tests indicate that the material can increase the amount of heat that a damaged tile radiates by about 70 to 160 degrees. An astronaut on a spacewalk would dab the wash on a damaged tile with a tool that looks like a shoe polish applicator.

Last summer, astronauts on the STS-114 mission tested the system on a tile during a spacewalk. "The crew was able to use the tool without incident or concern," says Steve Poulos, NASA's former manager of the shuttle's thermal systems.

Engineers are completing ground tests of how the wash would perform with different types of tile damage. "It's not a panacea," Poulos says, but the wash can make a marginal tile safer.

For bigger dings, astronauts may bolt on a 12- by 25-inch plate of carbon-silicon carbide composite. The plates are just .03 inch thick but are expected to provide the same thermal protections the original tiles did.

Currently, NASA plans to include both the plates and the emittance wash on the next shuttle mission: a *Discovery* flight, now scheduled for May. Says Poulos: "I'm very optimistic that by the end of this year, we'll have our repair capabilities done."



NASA (2)

All the shuttle's insulating tiles are marked for identification, useful for installation and accident investigation. Just 15 percent of the tiles on the shuttle's underside pose 85 percent of the risk of a tile-related accident.

Think small

The peculiar charm of the pint-sized airplane.

by Patricia Trenner

Wee Bee

Aeronautical engineers William Chana, Ken Coward, and Karl Montijo produced the all-metal Wee Bee in the late 1940s pretty much as a lark. Its 30-horsepower engine enabled a top speed of 82 mph. To fly it, its pilot lay atop the fuselage, making it an airshow attraction. The Wee Bee succumbed to a fire that swept the San Diego Aerospace Museum in 1978; a replica took its place.

Wingspan: 18 feet
Length: 14 feet 2 inches
Empty weight: 210 pounds

NASM 00099507

With genetics research making headlines on a regular basis, it's just a matter of time before the discovery of the "twee" gene, which confers a fondness for diminutiveness—dollhouses, teacup Chihuahuas, and Mini Coopers, for example. When this gene is dominant in people also carrying the prop-head gene, individuals are particularly drawn to wee aircraft. Further research will likely reveal that builders of such craft also carry the Guinness gene, which confers a congenital yearning to land in the record books.

Smallest Fighters

NASM 0070666

Westland-Hill Pterodactyl V >

The Pterodactyl was a British design of the 1920s created in response to a government request for a two-seat fighter. The rear cockpit accommodated a gunner, the wingtips pivoted to act as ailerons, and the wing trailing edge had elevators. A 600-horsepower Rolls-Royce Goshawk powered the tailless Pterodactyl, which ended up serving primarily as an airshow attraction.

Wingspan: 45 feet 6 inches
Length: 17 feet
Empty weight: 900 pounds

< McDonnell XF-85 Goblin

The U.S. Air Force lacked an ultra-long-range escort fighter for its ultra-long-range Convair B-36 bomber. McDonnell built the XF-85 to be stowed aboard the B-36. Instead of equipping the fighter with landing gear, a trapeze would extend from the mothership and a retractable hook on the Goblin did likewise to facilitate launch and retrieval. Most of the test retrievals, conducted with a B-29, resulted in collisions with the trapeze and belly landings by the Goblin, and the program was cancelled in late 1949.

Wingspan: 21 feet 1.5 inches
Length: 14 feet 10.5 inches
Empty weight: 3,740 pounds

NASM 00099706

Smallest Airliner

NASM 0009002

< Bellanca 14-9L Cruisair

North Carolina's State Airlines flew a three-seat Bellanca 14-9L from Charlotte to the South Carolina cities of Charleston and Columbia in the early 1940s. Along with a pilot and two passengers, the Cruisair could accommodate 60 pounds of baggage.

Wingspan: 34 feet 3 inches
Length: 21 feet 3 inches
Empty weight: 965 pounds

Bede 5J >

In the early 1970s, Jim Bede's audacious BD-5 kit (promising 200 mph on 40 horsepower) and BD-5J kit jet (276 mph, 202 pounds of thrust from a Micro Turbo TRS-18) rallied the homebuilder community like no other aircraft. But the company declared bankruptcy in 1979, by which time only a handful of BD-5Js were up and flying, mostly at airshows.

Wingspan: 17 feet
Length: 7 feet
Empty weight: 450 pounds

Smallest Jet

JIM KOEPNICK

Cri-Cri MC-10 >

French aeronautical engineer Michael Colomban designed the Cri-Cri in the early 1970s. Some 150 are registered around the world, primarily in France, where a seriously whack owner installed two minuscule turbojet engines on his, resulting in the world's smallest twin-jet. After selling his MC-10, Lewis Bjork wrote on a Cri-Cri Web site in 2003, "The fellow wanted it shipped via air freight and supposed it would make a good commuter for short trips over the jungle. I suggested he reconsider: engine failures common, can't start without big drill, needs special fuel. Not to be dissuaded, he claimed to weigh 110 pounds. For him, the airplane will be a rocket ship. He said if I ever come to Bangkok, drop by. I hope he is still happy to see me."

Wingspan: 16 feet 5 inches
Length: 12 feet 9 inches
Empty weight: 139 pounds

Smallest Sportplanes

NASM 00072746

< HM-14 Flying Flea (Pou de Ciel)

The original Tiny Airplane, the Pou de Ciel was designed by Henri Mignet in 1934. The upper wing acted as an elevator and there were no ailerons. Mignet's original design featured a 17-horsepower motorcycle engine. Later incarnations by homebuilders quadrupled the horsepower and also boosted the number of crashes, which led to a ban on the design in England and France. By the time a fix was in place, the novelty of the Flying Flea had largely worn off.

Wingspan: 18 feet
Length: 13 feet 6 inches
Empty weight: 260 pounds

NASM 7A47658

Smallest Sportplanes

NASM 00118908

Stits Sky Baby SA-2

Ray Stits built the SA-2 biplane in the early 1950s in Riverside, California, for no other reason than to claim it World's Smallest—clearly, a carrier of the Guinness gene. (Stits was the founder of the Experimental Aircraft Association's Chapter One, and also devised an eponymous aircraft fabric covering.) The Sky Baby is on display at the EAA museum in Oshkosh, Wisconsin.

Wingspan: 7 feet 2 inches
Length: 9 feet 10 inches
Empty weight: 452 pounds

Baby Bird

In 1984 Ray Stits' son Donald built the monoplane Baby Bird in Camarillo, California, to win the Guinness title of World's Smallest Monoplane.

Wingspan: 6 feet 3 inches
Length: 11 feet
Empty weight: 252 pounds

DON STITS

NASM 01073704

Mooney M-18 Mite

Debuting in the late 1940s, the Mite was the first single-seat general aviation production aircraft manufactured in the United States. Al Mooney marketed the M-18 as the Wee Scotsman and boasted of extraordinarily low operating costs and high-efficiency aerodynamics. Ex-military pilots said it handled like a fighter. Production ceased in the mid-1950s, and the "backward" vertical stabilizer went on to become a hallmark of the Mooney line of sleek and efficient (and larger) aircraft.

Wingspan: 26 feet 9 inches
Length: 17 feet 8 inches
Empty weight: 520 pounds

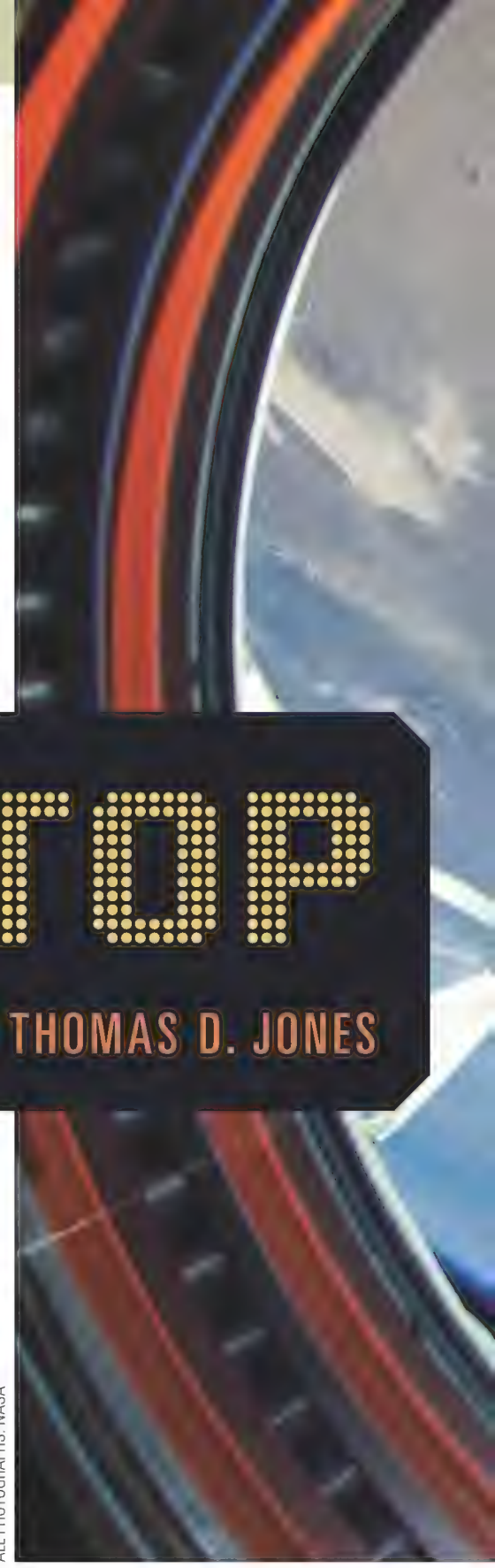
Bumble Bee II

Robert Starr, who flew the Sky Baby at airshows in the early 1950s, built the Bumble Bee II in Phoenix, Arizona, in 1988 to snatch the "World's Smallest" title from Stits. Guinness named it the World's Smallest Biplane. The airplane was destroyed in a crash; the original Bumble Bee is on display at the Pima Air and Space Museum in Tucson, Arizona.

Wingspan: 5 feet 6 inches
Length: 8 feet 10 inches
Empty weight: 396 pounds

SHUTTLE STOP

DOCKING DAY ON THE INTERNATIONAL SPACE STATION | BY THOMAS D. JONES



ALL PHOTOGRAPHS: NASA

Veteran astronaut Tom Jones gives readers an insider's look at spaceflight in his new book *Sky Walking: An Astronaut's Memoir* (Smithsonian Books/Collins). In this adapted excerpt, he recounts his STS-98 space shuttle crew's February 2001 mission to the International Space Station (here called *Alpha*). Among the station's other challenges, it tested the relationship between the United States and its former rival in space, Russia, as they worked together to build the largest and most complex structure ever placed in orbit.

Seven 600 feet away, I was getting nervous. The station's golden solar arrays and silvery white hull seemed motionless against the black sky, but I couldn't dismiss the fact that both ships were racing around the globe at five miles per second. Each of us concentrated on our cockpit tasks, and there was little superfluous chatter. The quiet was punctuated by the occasional thud of a thruster firing and the clicking shutters and whirring motor drives of our cameras. *Alpha* was an irresistible target for photography; it was etched so cleanly on the black sky above that my friend and crewmate Marsha Ivins said later, "It was as if someone had squeegeed my eyes."

I searched the faces of the others for signs of the tension I felt. Taco—Ken Cockrell—peered up through the overhead window in the aft cockpit, fingers curled around the hand controller for the shuttle's maneuvering thrusters. Taco was *Atlantis*' commander, piloting the orbiter through this crucial docking. This was his third space rendezvous as commander, but the most demanding yet, with the critical job of attaching the new Destiny science laboratory to the station. Mark Polansky—"Roman" to his friends—backed up Taco as pilot. As a rookie, this was his first rendezvous, and he was as focused and intense as I'd ever seen him. My spacewalking partner, Bob Curbeam—"Beamer"—babysat the docking system panel to Taco's right. Stationed in the right front seat, I served as the pilots' rendezvous assistant, riding herd on the checklist and our network of a half-dozen laptop computers. Marsha, on her fifth mission, would have the critical job after we docked of grappling the Destiny module from the payload bay and berthing it at the station. Now, as the "floater" for our rendezvous, she drifted face-up at the port aft window, rangefinder in one hand, camera in the other.

Marsha, having been to the Russian *Mir* station four years earlier, was less worried about the docking than tomorrow's berthing: Could the system—her brain and hands, the computers, the robot arm, the berthing latches and bolts—pull off the task, which required moving the 16-ton lab module around with clearances of only a few inches? The "I'm doomed!" T-shirt she wore during training was a none-too-subtle sign of her worries. Sweating out a session in the arm training rig back in Houston, she had peered up at the mockup of the massive lab hoisted high on the slender arm. "What are they thinking? This is nuts! 1.4 billion dollars!" she groaned inwardly. Later, after we were back on Earth, she would tell me how keenly she had felt the pressure: "The rest of you

guys just kind of guffawed around and joked and laughed, but every time I did the lab task I felt nauseous."

My own feelings about visiting the International Space Station had changed over time. More than once in the early 1990s, I thought NASA might be better off if it cut its losses and canceled the ISS. Was it really required to get us out of low Earth orbit and on the way to the moon, asteroids, or Mars? Or was it a dead-end distraction that would doom NASA to a cash-strapped future endlessly circling Earth?

By the time the author visited the space station in 2001, the view through the window of a docked shuttle (here, Discovery*) had become part of life in orbit.*

The five-year-old U.S.-Russian partnership, I felt, had been driven purely by NASA's need to salvage the space station (and NASA's bureaucratic prospects) under an indifferent administration that wanted to engage the Russians in some post-Cold War joint technology effort as a foreign policy exercise. But the realities of working with the creaky Russian space establishment had more than once threatened to drag the entire program down.

My cynicism slowly yielded to pragmatism as I recognized some hard facts. The administration would never give NASA the authority to jettison the Russians, no matter how difficult the partnership became. That would be a minor foreign policy disaster for the Clinton-Gore team. So for NASA, the road to the ISS had to go through Moscow. And my responsibility to NASA lay with moving the project forward if I could.

But at the moment politics was far from my mind. Now it was time to turn the orbiter around for docking. *Atlantis*, still headed nose-first along our direction of flight with the station above us, would bury her tail in the station's belly if we docked in this attitude, and we needed the payload bay and lab out in front of the station for berthing. So at 600 feet, Taco initiated a computer-aided yaw maneuver to swing our nose around 180 degrees. Above us, the station pivoted gracefully in our windows, mirroring the orbiter's actual motion. Three hundred feet now, closing as planned at 0.3 feet per second.

Backdropped against a desert landscape, Atlantis *departs the station with an empty cargo bay after a week-long visit. The delivery of the Destiny laboratory on STS-98, the seventh shuttle mission to the orbiting outpost, marked a transition from Russian to U.S. control. Earlier crews had worked mostly in Russian-built modules, taking direction from mission control in Moscow.*

Floating in the overhead window with her laser rangefinder, a modified version of a state trooper's speed gun, Marsha called out the distance and closing rate. Beamer had the docking system in the green, ready for contact. Roman was now backing up Taco, monitoring the approach and occasionally squeezing off a photo. I called the range rate numbers to Taco every 10 feet or so, the checklist going just like clockwork.

Atlantis glided up the corridor, closing steadily. At 170 feet, Taco fired thrusters and brought us to a temporary halt, a chance for everyone, in orbit and on the ground, to take a deep breath before pressing in for docking. The Expedition One crew on the station called that they were ready, and Moscow confirmed that its systems aboard the ISS were go. Houston agreed: "*Atlantis*, you're go for docking." With two quick pulses, Taco started us upward toward our meeting with the International Space Station.

At two feet every 10 seconds, it would take us nearly 15 minutes before our docking ring contacted *Alpha*'s. At 100 feet the radar echoes grew too noisy for accurate ranging, so we switched solely to laser data.

In the darkness of orbital night, the station hovered in the wan glow of our payload bay floodlights, its feathery solar arrays fading into the inky gloom. Earth was forgotten. All eyes were focused on the station as its bulk slowly hove into the light, like a shipwreck emerging from the gloom of the deep ocean. *Atlantis* weighed about 120 tons, the ISS about 100, and the two vehicles seemed to squeeze the vacuum between them as they closed the remaining distance.

Inside 100 feet, Taco let the closing rate slow to 0.1 foot per second. We were within one shuttle length of *Alpha*. Houston was quiet; responsibility for the docking was now in our hands. Our lights clearly illuminated the target mounted on the station's tightly sealed hatch: The docking ring above seemed close enough to touch. Roman and I crowded up to the TV monitors and stared hard at the zoomed-in target image. The alignment cross was neatly centered in the bull's-eye; we told Taco that the approach errors were insignificant.

"Houston," he called. "We don't see a fly-out required. We're pressing in." Mario Runco, the astronaut capcom in mission control, answered promptly: "We concur."

Across 30 feet of emptiness, Taco made a final call to Shep [Bill Shepherd] and his station crew: "*Alpha*, *Atlantis*, here we come."

With a barely perceptible pulse from the thrusters, Taco nudged us upward, and Marsha started the range calls again. On her *Mir* mission, she said, the approach was "much less excruciating" because the shuttle docking ring was farther aft; this time the controlled collision would happen just outside our windows.

At 15 feet, she began reading ranges directly off the template on the TV monitor. At the closing rate of 0.1 foot per second, Taco's margin for error was just 0.03 foot. Too fast and he might bounce the orbiter's docking ring off the station. Too slow and the capture latches might not snap firmly home.

"Fourteen feet, point one two."

"Twelve feet, point one one."

Russian cosmonauts Sergei Krikalev (left) and Yuri Gidzenko welcome Mark Polansky aboard the station on Flight Day 3. The early station crews alternated between an American commander with two Russians and a Russian commander with two Americans. The crew size was reduced to two after the 2003 Columbia *accident, but will go back to three this year.*

Taco's eyes were fixed on the target above. Drifting just three inches off-center would put us outside the docking envelope and force an abort.

"Ten feet, zero point nine on the R-dot," I called out, glancing at the laptop. My voice rose a notch in both volume and pitch.

Up in the commander's seat, Roman powered up the firing circuit for the automatic thruster sequence to be triggered two inches from contact. "PCT [post-contact thrusting] is armed," he announced. The computer-controlled shove would bang the shuttle's and station's docking rings together with enough force to guarantee capture. The last few feet came in a rush.

"Six feet, point one one."

From the cockpit, the station seemed to descend on us like a giant industrial press, an enormous mass bent on ramming straight through the cargo bay. I tensed for the impact even as I called out the remaining distance.

"Eighteen inches, R-dot is good."

"One foot, petal overlap." The three metal alignment vanes atop each docking ring swept past each other toward impact.

"Six inches…two inches!"

Just before the rings slammed together, Taco mashed the PCT button on the autopilot panel. *Atlantis* shook with thruster firings as the force of the impact compressed the shock absorbers of the docking rings.

Two blue lights flashed on the docking panel. "Capture!" called Beamer. The two spaceships bobbed gently, held lightly together by the latches on the docking petals. Dampening springs quickly brought the motion to a halt.

"Capture confirmed, Houston," radioed Taco, satisfaction obvious in his voice.

"Nice job!" Mario replied. "Nice approach."

In the cockpit, the crew shook hands and smiled in relief. I felt drained but elated—we'd pulled it off; we were safely docked!

Sunrise glowed first a pure blue, then pink, then silver-white across the Russian solar power arrays visible out front. In the harsh sunlight now washing over us, the entire station came into sharp focus. Taco could relax at last. Later he told me, "I was so psyched for the docking, and so trained for it, that I actually felt a little let down when it was over. Things went so smoothly that I felt, somehow, that there should have been more drama, or more angst (Marsha's influence, maybe?), or more…something."

The two docking tunnels now formed a slender vestibule between a pair of sealed hatches, one on *Atlantis*, another above in the station's Pressurized Mating Adapter. Working with me in the airlock, Beamer quickly equalized the pressure between our

Rose-colored glasses: The station as seen through the crew optical alignment system during a previous mission. With its crosshairs and hash marks, the COAS is a useful tool for docking.

Five-time astronaut Marsha Ivins (left, with zero-G hair) had paid an earlier visit to the Russian Mir *space station and found* Alpha *cleaner and better smelling. Below, the STS-98 crew (from left, "Beamer" Curbeam, "Roman" Polansky, "Taco" Cockrell, the author, and Ivins) goes for a variation on the obligatory crew shot from inside the Destiny laboratory.*

cabin and the tunnel vestibule just above. Through the upper hatch window, we could see Shep, Sergei Krikalev, and Yuri Gidzenko opening the station hatch on their side.

We were ready for a reunion. Taco swam up through the airlock and joined us below the hatch. He peered up through the port, giving the Expedition One crew a quick wave.

"Everything ready, Tom?" Taco grinned; I should have seen it coming. "Let's see how you do opening up *this* hatch"—a sly reference to the jammed hatch that had thwarted my planned spacewalk on a previous mission (see "No Way Out," June/July 2002). I cranked the handle smoothly through a full circle. A quick tug and the hatch came off the seals, mingling the atmospheres of the two spaceships. With Beamer's help on the stiff hinges, we swung the hatch down and flush against the airlock wall. Just like that, the door was open and the five of us floated aboard the space station.

Taco, a body length above me, rose into the burly embrace of a grinning Shep and two exuberant Russians. Drifting after him with Beamer, Roman, and Marsha, I entered the roomy world of the International Space Station. Shep, Yuri, and Sergei met us in their "foyer"; for a few minutes the Node, its trim a cheerful salmon color, was a scene of friendly chaos as we traded hugs, handshakes, and huge grins with our colleagues. The Expedition One crew had been on their own since *Endeavour*'s astronauts had departed nearly two months before, and they were delighted to see visitors, especially visitors bearing a lab-size housewarming gift.

Marsha later recalled her first impression: "Cleaner, compared to *Mir*. Cleaner and smelled a whole lot better." The ISS surprised me too: It wasn't some austere outpost, clinging to the very edge of human existence. It was a home port in space. The Node's roomy interior, warmer temperature, and softer lighting made it cozy, compared with the shuttle's cramped, sterile cabin.

Shep formally welcomed us aboard with a brief speech over the radio to both control centers, and a ceremonial ringing of the ship's bell he had installed above the port hatch (he'd been a Navy SEAL). For the next week, the eight of us would work together as one crew. I looked forward to it, although the three space station astronauts were only casual friends of mine. I didn't know Shep well, and he'd been scarce at NASA during the past few years, with most of his time spent in Russia. During Sergei's shuttle training in Houston, I had enjoyed collaborating with him on a scientific paper. Yuri I knew only through his reputation as a well-regarded cosmonaut.

Marsha was closest to Shep. Both members of the 1984 astronaut class, they had a lot of catching up to do. "Shep wanted to know what was going on in the world…what was going on in the [Astronaut] Office," she said. "I thought, playing with my crew is fine, but playing, talking, hanging out with these guys is a short moment in time, and I ought to take advantage of it."

We moved on to the Russian-built Service Module for a quick safety briefing and tour; then our hosts returned with us to *Atlantis*. Over the next few hours we inventoried and turned over to Shep's crew a half-dozen suitcase-size bags

The STS-98 crew photographed their handiwork as they backed away from the station on February 16, 2001. The newly attached Destiny laboratory is the cylindrical module at center. The station's gold solar power arrays extend vertically at right.

of priority cargo. Included was a locker full of fresh foods and snacks, a welcome break from the freeze-dried, canned, and thermostabilized fare they had been eating for more than three months. Four hours after boarding the ISS we were back in *Atlantis*, closing the hatch to prepare for our spacewalk the next day.

Taco and Roman sent air whistling overboard through the airlock depress valve, lowering the cabin pressure to 10.2 pounds per square inch. The reduction from sea-level pressure would bring down the nitrogen content of our blood, reducing our chances of getting the bends and shortening the time we'd spend the next morning in our spacesuits, preparing for our first spacewalk, or extravehicular activity (EVA). To further lower our blood nitrogen levels, Beamer and I donned portable breathing masks to begin flushing that unwanted gas from our lungs. Looking like a couple of wayward scuba divers, we breathed pure oxygen while readying the EVA tools. We quickly located nearly every item on the checklist, but three critical electrical components, called loopbacks, were missing.

For months we had trained underwater to install these soda-can-size plugs on the lab's hull, where they would shunt electrical power or data to the proper circuits. These had to be in place for lab activation after EVA 1. We searched our lockers again for the loopbacks, and Marsha checked her inventory sheets. No loopbacks, but she did find several listed items called "1553 bus terminators."

No doubt at some point in our training we had been exposed to the proper technical name for the loopbacks, but none of us had ever used that term. We quickly realized that "1553 bus terminators" probably referred to the missing parts. A call to Houston confirmed our fears: The lost components had been packed in one of the cargo bags we had just transferred to the station. They were now on the wrong side of a sealed hatch.

The pressure differential between the two vehicles prevented us from simply opening hatches and grabbing the parts. My first thought was that we would have to repressurize either our cabin or the station's docking tunnel, wasting precious breathing gas in the process. I had just made the call to Houston admitting our mistake when Sergei made a suggestion. Because the loopbacks were only the size of a six-pack, he could place them in the foot-wide vestibule between the orbiter and station hatches; it would take just a few liters of air to equalize the pressure there, making it safe for us to retrieve them.

Sergei's solution soon had us back in business. As I grabbed the loopbacks from the vestibule, I met his gaze through the porthole in the Russian-built station hatch. He returned my nod and wave of thanks with an easy smile. The irony of having a former Communist rescue our first spacewalk from an embarrassing foul-up wasn't lost on me, a former Cold Warrior who'd spent my Air Force days flying B-52 bombers. This partnership might yet work.

Barnstorming the Beltway | *Little Gee Bee*

After World War II the Civil Aeronautics Administration, expecting a boom in private flying as pilots returned from overseas, issued regulations governing the production of light aircraft. The expectation was that new airplanes would be built in factories and meet federal guidelines. Private citizens who wanted to build their own aircraft were left in limbo. Homebuilts were not expressly forbidden, but licensing limitations were so restrictive that such airplanes would have no practical use.

This didn't go over well, particularly in Oregon. In the pre-war years it had been possible to build and fly airplanes there on a state license, without government interference. Pioneers like Oregon farmer and mechanic Les Long inspired small groups of young men who wanted to fly. They built—and re-built—small airplanes in barns and flew them from pastures. It was exciting stuff, especially in the dreary years of the Depression. Now, it looked like bureaucrats in Washington, D.C. were going to kill the fun.

In 1947, George Bogardus, from tiny Troutdale, Oregon, wanted to prove that homebuilt airplanes deserved better. He refurbished a single-seat, 65-horsepower airplane built before the war by Oregonian Tom Story. He finagled a special permit to fly the airplane, now christened *Little Gee Bee*, to Washington, D.C. (The airplane had no relation to the famous Gee Bee racers built by the Granville brothers; George Bogardus may have liked the play on his initials.)

His flight must have been quite an adventure. Sixty-five horsepower is pretty minimal for the mountainous West, and the rigid seat that Story welded into the airplane must have tortured the six-foot-one Bogardus. Stopping along the way to recruit members for what he called the American Airman's Association, he landed safely, eight days later, in Deer Park, Long Island. From there, he and other members of the group flew to Washington, where they lobbied the CAA to write regulations making it legal to build one's own airplane.

He was politely received and some temporary provisions were enacted. Not satisfied, Bogardus repeated the trip in 1951. Finally the CAA, (which became the Federal Aviation Administration in 1958) wrote a provision specifically allowing individuals to build and license airplanes in an "experimental" category for their own "education and recreation."

His mission accomplished, Bogardus returned to Oregon, carved out a tiny airstrip on his property, and then dismantled *Little Gee Bee* and stored it in a shed. Increasingly reclusive, he faded from the aviation scene. His American Airman's Association never developed, but a similar group, the Experimental Aircraft Association (Bogardus was said to regard it as a rival), has grown into one of the largest aviation organizations in the world.

Bogardus died in 1997 and, surprisingly, left his estate to his local EAA chapter. One chapter member, Dick VanGrunsven, who had as a teenager been enthralled with airplanes, had often flown his Taylorcraft onto Bogardus' strip for visits. The designer of a line of kit aircraft, VanGrunsven headed a crew that cleaned up the property. It was a major task; Bogardus was a bit of a pack rat. After removing airplane parts, sundry mechanical debris, and towering piles of old magazines, they found *Little Gee Bee* where Bogardus had stored it, 45 years earlier.

The airplane was in rough shape. The engine was disassembled and the pieces thrown into several boxes. The fabric covering was nearly gone; it survived only on one wing and part of the other. The wheels were badly corroded and the tires were rotted beyond redemption.

Eventually, *Little Gee Bee* was moved to VanGrunsven's shop in North Plains,

COURTESY DEAN SIGLER (2)

George Bogardus modified Little Gee Bee *for the many cross-country trips he flew. He added a fuel tank behind his seat and hand-pumped avgas through a rubber tube to the main tank behind the engine. Right:* Little Gee Bee *rests at Deer Park, Long Island, after making a 2,457-mile flight.*

r a t i o n

JERRY VANGRUNSVEN (4)

Above: Mike Story bead-blasts the fuselage his father built the year Mike was born.

Above: The naked Gee Bee *sits in Dick VanGrunsven's Oregon front yard. Surprisingly, steel fittings in the wing were still useable, so after cleaning and painting, they were re-installed. Right: VanGrunsven carefully removes delicate, 50-year-old fabric from the airplane's rudder, while (top right) his brother recovers the tail surfaces.*

Oregon. There, Dick, his brother Jerry, and a band of volunteers met every Saturday to rebuild it. One of the first to show up was Mike Story, son of the original builder.

"*Little Gee Bee* evolved from one of Les Long's designs," says VanGrunsven. "In the '30s my father flew from Long's field—it's just a few miles from here—and he always mentioned Les' talent with great respect.

Inspecting this airplane confirms that. It's an elegant design, with a very light, strong structure that gets the best out of the small engine. The steel-tube fuselage is beautifully welded.... Tom Story was an artist with a torch. Everything about the airplane is simple, but it all worked and worked well."

"My dad was a builder," says Mike Story. "He built about 14 airplanes and a complete car, but when he was through, they'd sort of go away. Then he'd just start building something else."

After the fuselage was sandblasted, repainted, and recovered, the corroded aluminum leading edges of the wings were replaced and the rotted wood ribs rebuilt. The Sensenich Propeller Company reconditioned the wood propeller. No original tires or wheels could be located, so another VanGrunsven brother, Stan, restored the original wheels and machined adapters to accommodate Piper Cub tires.

By this spring, *Little Gee Bee* was almost completely restored and destined for a spot in the Smithsonian's National Air and Space Museum.

Dick VanGrunsven believes the aircraft deserves the honor. "By itself, it's just another little airplane, but in the historic sense, it's a heck of an ancestor," he says. "About one out of five airplanes registered today is amateur-built—even SpaceShipOne is registered in the Experimental category. They can all be traced back to *Little Gee Bee*."

—Ken Scott

'ORCHESTRATED

ROYAL AIR FORCE WING COMMANDER Jock Abercrombie and other pilots of Bomber Command gathered at mid-afternoon on Thursday, December 2, 1943, to find out the day's weather, which was cloudy, and the day's target, which was Berlin. On that night's mission, Abercrombie's four-engine bomber, an Avro Lancaster with the nose art *D for Dog*, would carry to the German capital five tons of high explosives and one passenger. The passenger was the chief CBS radio correspondent in Europe, Edward R. Murrow.

Murrow was likely the most influential private U.S. citizen during the Second World War. In London during the Blitz, he had his own, personal, finest hour. Each night, standing exposed on rooftops, he gave to an American audience of 20 million live coverage of the city's bombardment and its citizens' resilience. Introduced with the trademark phrase "This… is London," Murrow's reports converted many of his listeners from isolationists into sup-

HELL'

Edward R. Murrow's famous broadcast on bombing Berlin.

by Mark Bernstein

LEFT: IMPERIAL WAR MUSEUM; ABOVE POPPERFOTO/ALAMY

porters of the British cause. Speaking back in the United States in 1938, he told his audience, "Whether we like it or not, the answer to Europe's problems will be found, not in Europe, but right here in the United States."

Murrow would make his flight on *D for Dog* the subject of a 17-minute radio broadcast, the longest he gave during the war. With it, he transported his audience from their comfortable living rooms to the cold belly of a big black Lancaster. Listening to it now, 60-plus years later, we feel what he felt: the bumpy ride, the considerable fear, the mission accomplished, and the relief of safe return. (The recording can be downloaded from *www.otr.com/orch_hell.shtml*.)

The strategic bombing of Germany—of which *D for Dog*'s mission was a tiny part—remains a matter of debate among historians. Drawing upon military records, the recollec-

On 156,308 sorties, flown mostly at night and against heavy defenses, World War II Lancaster crews battered German cities and industrial centers. Forcing the enemy to concentrate on defense had its cost: Bomber Command suffered a higher casualty rate than any other part of the British military.

GETTY IMAGES

Edward R. Murrow in 1941 London. In February, a state-run preservation group designated as historic the London apartment house where the broadcaster lived.

tions of crew members, economic data, and other sources, historians have both defended and condemned the policy. Murrow's broadcast also makes a judgment, and it is interesting to hear the conviction in the newsman's words after reading the contentious analysis published in the years since he spoke them. As historians I interviewed point out, such eyewitness reporting suffers from a shortage of available fact and the pressure of deadline. "What you can get from a broadcast is a powerful impression," says Richard Overy, author of a dozen histories of World War II, including *The Air War: 1939–1945*. "You don't get an answer to the broader questions historians ask: Why were the airplanes there? What were they doing? Did they have any effect?"

Yet eyewitness reporters like Murrow can provide what better researched interpretations may lack: a sense of participation in history. We feel that we are there with Murrow from the very first words of his broadcast: "Last night, some of the young gentlemen of the RAF took me to Berlin."

The United Kingdom and Germany began exchanging bombs in August 1940, when German bombs intended for an airfield on the outskirts of London landed instead on the city. The U.K. retaliated with attacks on Berlin, and Germany launched the Blitz on London that, among other things, made Murrow a household name. Initially, the British missions against Germany did little more than show the flag—Britain's bombers were few, their payloads small, and the navigation highly erratic. In late 1941, it was determined that only one aircraft in three managed to drop its payload within five miles of its target. The British adopted a policy of "area bombing" cities—later the subject of considerable controversy—in part because a city was the smallest target that British bombers, operating under the cloak of night, could identify.

"Let me ride in a bomber," he told CBS president William Paley, "and I can know a little better how the pilot feels when the tail is shot off."

By the time Murrow boarded *D for Dog*, strategic bombing had become central to Allied war policy. Between the fall of France in June 1940 and the landings in Italy in September 1943, no Western army engaged the Germans on the continent of Europe. Bombs were the only weapon available. As Prime Minister Winston Churchill wrote to Lord Beaverbrook, his minister for aircraft production, "We have no continental army which can defeat the German military power.... [T]here is only one thing that will bring [Hitler] down, and that is an absolutely devastating, exterminating attack by very heavy bombers from this country upon the Nazi homeland."

Britain committed a quarter or more of its war production to strategic bombers. In February 1942, British military leadership gave command of this air arm to Arthur "Bomber" Harris, whose views of warfare were notably unromantic: "We are going to scourge the Third Reich from end to end. We are bombing Germany city by city and ever more terribly in order to make it impossible for her to go on with the war. That is our object, and we shall pursue it relentlessly."

Murrow was also relentless. During the Blitz, he had received permission to broadcast live from London by taking his case to the prime minister, Winston Churchill. Churchill, formerly a correspondent in the Boer War who believed that Murrow's reports would dramatize England's underdog status and would therefore appeal to Americans, overrode layers of British officialdom and got Murrow on those rooftops. With American entry into the war, Murrow's circumstance changed. After Pearl Harbor, his wife, Janet Brewster Murrow, said Murrow felt "uncomfortable" in civilian dress. He tried to enlist but was told his reporting was a greater contribution to the war effort. So he tried to get closer to the action: For the whole of 1943, he badgered British officials and his superiors at CBS to get on a bombing run. (Apparently the U.S. Army was more tractable. Newspaper reporters, including Walter Cronkite and Andy Rooney, went along on the first B-17 mission into Germany in January 1943.)

Ostensibly, Murrow's motive was accuracy: "Let me ride in a bomber," he told CBS president William Paley, "and I can know a little better how the pilot feels when the tail is shot off." But Murrow wasn't satisfied with a single ride.

He went along on 23 more combat missions, including a September 1944 ride on a transport delivering paratroops for the ill-fated Market Garden assault (the subject of the book and movie *A Bridge Too Far*).We may wonder about his motivation for these other flights; his broadcast of December 3, 1943, was the only one he made about his experience of the bomber war.

The principal aim of strategic bombing, Richard Overy writes, is to undermine an enemy's capability to wage war. During World War II, combatants hoped to cripple the enemy's production capability through continual attack on industrial targets, and, by strikes on non-military targets, to destroy the will of the citizenry to continue the fight. Although the original orders to the Luftwaffe were to destroy the British air capability, by the end of 1940 German airplanes were deliberately targeting population centers like Coventry, an industrial city the Germans set infamously ablaze with incendiary bombs and high explosives. In return, England launched thousand-bomber raids in 1943 over Cologne, Essen, and Bremen. In May of that year, 19 specially trained Lancaster aircrews destroyed dams on the Ruhr, spilling flood waters down the Ruhr Valley for 50 miles, extinguishing blast furnaces and flooding coal mines. Fifty-six of the 133 crewmen died in the assault.

NASM (SI NEG. #85-18328)

Londoners inspect the damage following a night raid. After 57 consecutive nights of German attacks, 375,000 Londoners were left homeless.

Some raids were devastating. Almost 600 factories were obliterated in a July mission over Hamburg, and an estimated 42,000 people died. Hamburg, wrote Hitler's armaments chief, Albert Speer, "put the fear of God in me."

The results of attacks on strictly industrial sites were less definitive. A costly Bomber Command raid in August against Germany's crucial ball bearing works at Schweinfurt, German sources reported, cut production by 38 percent, but in the following weeks, output was largely restored.

As 1943 progressed, a greater share of the air war against Germany was conducted by the U.S. Eighth Air Force, which had been established in Britain by June 1942. The Americans took a fundamentally different approach to bombing.

To arm a Lancaster for a typical run, crews loaded up to 14,000 pounds of bombs in its 33-foot-long bomb bay.

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The British almost always bombed at night; the Americans held that their more heavily armed B-17s and B-24s were, when operating en masse, sufficiently self-defending to fly in daylight. That strategy allowed use of the highly accurate Norden bombsight.

Daylight operations proved, however, equally hazardous. In October, the Eighth Air Force sent 290 bombers on a second attack of Schweinfurt. The attack temporarily cut production by two-thirds. The cost was startling: 60 aircraft shot down. Given that cost, further attacks on the site were curtailed, to what Speer called his "overwhelming relief."

The British aircraft that played the most effective part in the bombing was the type Murrow rode to Berlin, the Avro Lancaster, arguably the finest heavy bomber of the European war. Although the Lancaster was a touch slower than the B-17, it could carry 14,000 pounds of bombs to Berlin. Max Hastings, author of *Bomber Command: Myths and Reality of the Strategic Bombing Offensive*, says, "The Lancaster was a stupendously reliable piece of machinery; crews had enormous confidence in it." The Lancaster entered service in early 1942. In May of that year, Great Britain had only 29 of them; by January 1943, it had 178, and they made up better than a third of its frontline component. Historian Robin Neillands, who interviewed dozens of Bomber

POPPERFOTO/ALAMY

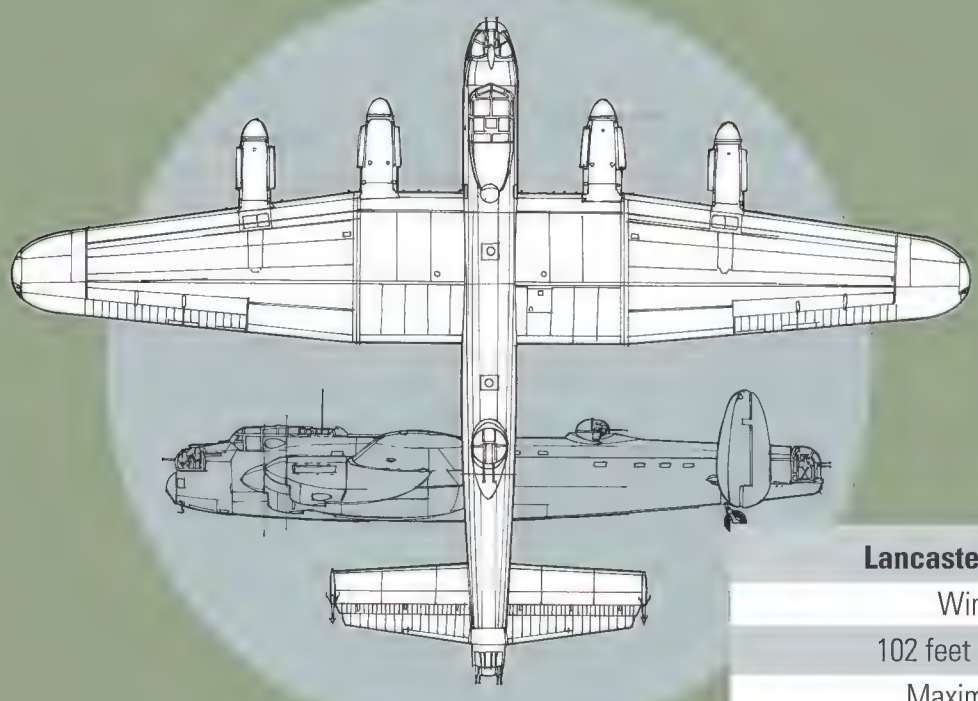
Bombing Germany had strategic objectives, but the British population, historians admit, saw it as payback.

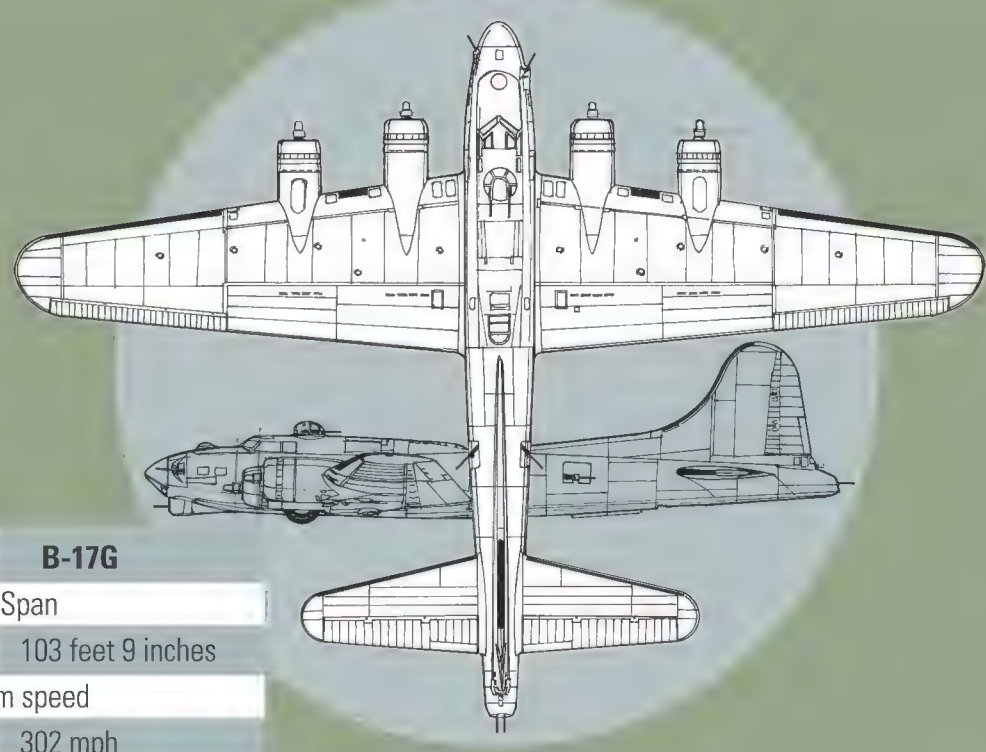
Command veterans for his book *The Bomber War*, says, "They adored the Lancaster."

Preparing for takeoff, Murrow and *D for Dog*'s crew pulled on parachutes and Mae West vests. Parachutes were an uncertain asset. For all its strengths, the Lancaster was a difficult aircraft to get out of in a crisis—only about one in six crewmen shot down reached the ground alive. As *D for Dog*'s crew waited to board, a small station wagon drew up delivering for each man a thermos of coffee, chewing gum,

The Lancaster Versus the Flying Fortress

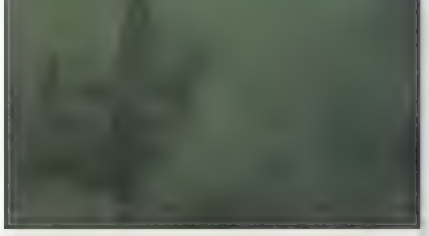
Although the Royal Air Force battle-tested B-17s in July 1941 (with poor results), the U.S. bomber didn't really get into the fight in Europe until 1943, when Eighth Air Force crews flew it and B-24 Liberators against Germany on daylight missions. The B-17 is an earlier design than the Lancaster, but each occupies the same heroic status in its country's military lore. Lancasters could carry more bombs to the target, but B-17s had Norden bombsights, which could get the bombs on the target.



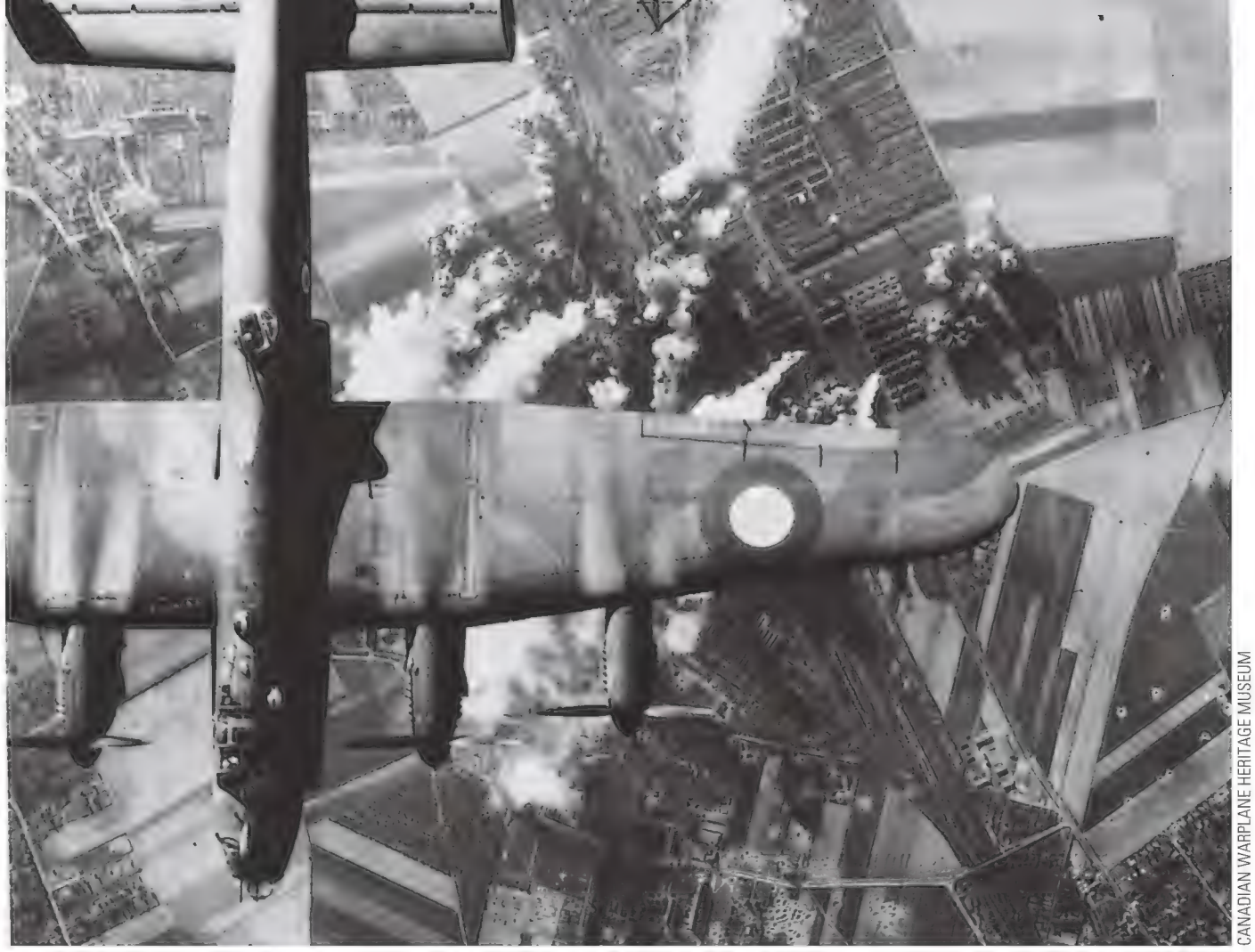


HARRY WHITVER

	Lancaster	B-17G
Wing Span	102 feet	103 feet 9 inches
Maximum speed	287 mph	302 mph
Typical Payload	14,000 pounds	6,000 pounds
Range	1,660 miles	2,000 miles



"D-Dog seemed to be standing still, the four propellers thrashing the air. But we didn't seem to be closing in."



CANADIAN WARPLANE HERITAGE MUSEUM

German air defenses were so weakened by 1945 that Lancs could attack in daylight. Another bomber made this photo; the subject, therefore, was in a precarious position.

an orange, and a square of chocolate. With that, the aircraft took off into what Murrow in his broadcast would term a "dead, silent, and expectant" sky.

In the broadcast, Murrow introduced the crew by their first names only. The Lancaster had a high cockpit, 19 feet above the ground. Jock, the pilot, sat there, with the flight engineer at his side. The navigator—on *D for Dog*, his name was Dave—sat behind the pilot at a small curtained-off table lit by a pinpoint lamp; Titch, the wireless operator, was backed against the main spar. His dispatches would be few and brief: German radio-interception equipment was so sensitive, according to Neillands, it could pick up the sounds of radio sets in England warming up prior to takeoff. Farther back were Boz, the bomb aimer; Wally, the mid-upper gunner; and Jack, the tail gunner. The rear gunner, Neillands writes, had the worst job: "stuck on his own at the far end of a vibrating fuselage; sucking on an oxygen line; particularly vulnerable to aircraft coming from astern." *D for Dog*'s crew members were likely young: Most bomber personnel were between 19 and 22. All were volunteers.

Early in the war, the pilot was thought to be the key to success, but experience taught that crews survived only as a team. Perhaps reflecting this, Murrow would broadcast that as the flight advanced toward Germany, "Jack in the rear turret, Wally, the mid-upper gunner, Titch, the wireless operator—all seemed somehow to draw closer to Jock in the cockpit. It was as though each man's shoulder was against the others'."

In 1943, bombers left England with fighter cover but arrived at many targets unescorted. Not until spring 1944 did the United Kingdom get the North American P-51B Mustang, which had the range to escort bombers all the way to Berlin. After the fighters accompanying the December 2 mission turned back, Murrow reported, "Jock looked up at a vapor trail curling across above us, remarking in a conversational tone that from the look of it he thought there was a fighter up there."

The German night fighters were the striking arm of an integrated air defense system of radar, searchlights, and anti-aircraft guns. Allied aircrews developed considerable respect for their foe. Once, after the German Focke-Wulf fighter was introduced, a poster was hung in a crew room picturing a bomber pilot asking, rhetorically, "Who's afraid of the new Focke-Wulf?" Someone pinned paper to the poster and, not rhetorically, every member of the unit signed.

When *D for Dog* reached Germany, Murrow began to see flak explode. It looked, he reported, "like a cigarette lighter in a dark room—one that won't light. Sparks but no flame." The flak most feared came from the German 88-mm gun. This versatile weapon, highly potent against tanks in land combat, could send a shell five miles high in seven seconds. When Murrow asked the pilot to estimate how close the flak bursts were to the aircraft, he responded, "Not very close. When they're really near, you can smell 'em."

Murrow's own apprehension rose: Thirty miles from Berlin, he later broadcast, "*D-Dog* seemed to be standing still, the four propellers thrashing the air. But we didn't seem to be closing in." Cloud cover was "ten tenths"—complete. Instantly, the dirty gray clouds turned white; the aircraft was caught in the gleam of searchlights. Describing the vulnerability of being in a dark aircraft cast against suddenly gleaming clouds, Murrow reported: "*D-Dog* seemed like a black bug on a white sheet." The pilot wore gloves with the fingers cut off; Murrow saw his fingernails turn white as he gripped the wheel. Sensing danger, the pilot whipped the aircraft into a climbing turn that dropped Murrow to his knees. Some pilots, Max Hastings notes, banked cautiously for fear of losing a wing; "[o]thers—the ones who lived—recognized that the danger of a wing collapsing was nothing as that of a fighter's cannon."

Jock and Boz, the bomb aimer, considered the target, wreathed with smoke. Murrow described the exchange: "Boz said he liked the two green flares on the ground almost dead ahead." Soon thereafter, "there was a gentle, upward thrust under my feet, and Boz said: 'Cookie gone'…

'Not the city you knew'

Howard K. Smith was the final CBS correspondent in Berlin, prior to U.S. entry into the war. In late 1941, the German Ministry for Propaganda and Public Enlightenment kicked Smith off the air for refusing to read prepared statements as news; his office was searched by the Gestapo. He was given two days to leave the country. Providentially, that order came on December 6, 1941—had he stayed in Germany another 24 hours, he might have ended up an enemy alien. Smith then reported for CBS from Switzerland. Following D-Day, he and his Danish wife, Bennie, crossed into France and managed to get to Paris, where Edward Murrow assigned Smith to cover the American Ninth Army.

Smith returned to Berlin on May 9, 1945, as the only broadcast reporter to witness the Germans' second surrender—this time to the Russians. Wishing to visit his old neighborhood, he assured a U.S. officer that he knew the city well enough to go unescorted. "You will find," the officer replied, "that it is not the city you knew."

Smith did see Berlin, tagging along on a tour undertaken by Sir Arthur Tedder, air chief marshal of the Royal Air Force, and General Carl Spaatz, U.S. commander of Army strategic bombing forces. These two, Smith noted in his subsequent broadcast, had been principal planners of the bombing of Berlin. "Today, for the first time," he said, "they saw the results from the ground."

© BETTMANN/CORBIS

Bombs destroyed 20 percent of the housing units in Germany, mainly in the targeted cities.

When Tedder and Spaatz stood before the Reichstag, "they said nothing. There are no words capable of encompassing that vast scene of desolation." Where the party had intended to drive, the rubble was too deep. They improvised a roundabout route: "The ruins, themselves, had been pounded then re-pounded and re-pounded, until there's no more rubble of bricks and parts of bricks. All there is left is dust, fine, powdery pale red dust that you can sink down to the hubcaps in. The car ahead was just fifty yards away and it was moving slowly. But it churned up so much dust, we couldn't see it."

One of the few buildings in Berlin to survive three years of bombing was the headquarters of the German air ministry.

and *D-Dog* seemed lighter and easier to handle."

Murrow's December 2-3 flight to Berlin was the fifth of 16 air assaults launched against the German capital between November 18, 1943, and March 2, 1944. Arthur Harris believed this air campaign would cost the Allies between 400 and 500 aircraft, but that "it will cost Germany the war."

Only the first prediction came true. Of the 500 aircraft sent out just on the night Murrow flew, 50 were shot down. At the end of the mission, Murrow telephoned his wife. Janet Murrow later reported, "He sounded shaken."

Near midnight, London time, on December 3, Murrow presented 20 million American listeners with his account of *D for Dog*'s attack on Berlin. Murrow recounted the mission, which from his airborne, buffeted vantage appeared to turn the German capital into "a thing of orchestrated hell—a terrible symphony of light and flame." He also commented on the matter-of-factness of those engaged in the effort. The bomber crews, he said, speak of it as a job: "[A] young pilot with old eyes said to me: 'I see we're working again tonight.' " Another comment showed that Murrow had no illusion that the suffering was limited to the aircrews: "Men die in the sky while others are roasted alive in their cellars." It was, he noted, a "calculated, remorseless campaign of destruction." It was a campaign, not incidentally, that a month later would claim the life of *D for Dog*'s pilot, Jock Abercrombie.

Arthur Harris remained determined. On December 7, four days after Murrow returned to London, he predicted a German surrender by April 1, 1944. But Berlin was a city of stone buildings, with wide avenues that acted as firebreaks, and the destruction, though great, was not sufficient to force Germany to negotiate terms of surrender.

Richard Overy argues that strategic bombing, unlike combat on the ground, does not produce sharply defined victories or defeats. It does not win territories or lose them; rather, its effects are cumulative. "The Battle of Berlin," he says, "continued the process of having the Germans pull back their resources from the defense of the Rhine, and [required them] to decentralize their production. In that sense it was no more or less a failure than other attacks. Berlin's a big target; it's a rather difficult thing to destroy."

Robin Neillands offers a less positive judgment of the series of raids: "Harris did not have the aircraft to shatter Berlin quickly and had to divert to other targets to prevent the buildup of flak and fighter resistance over the big city."

Controversy over the strategy began during the war itself, even before Murrow took his ride on *D for Dog*. Rising in Parliament in March 1943, Member Richard Stokes asked whether the government was "aware that a growing volume of opinion in this country considers indiscriminate bombing of civilian centers both morally wrong and strategic lunacy?" In fact, those who openly opposed strategic bombing were few, but included persons of standing: A.V. Hill, one of the developers of radar; historian A.J.P. Taylor; military theorist Basil Liddell Hart; and the Bishop of Chichester.

CBS VIA GETTY IMAGES

In September 1953, Murrow returned to Berlin for a CBS television news series about the city stranded in a divided Germany. The following year, Murrow enhanced his reputation with a famous telecast that challenged Senator Joseph R. McCarthy, an event that inspired the current feature film, Good Night, and Good Luck.

"The terrible symphony of light and flame" that D for Dog and 500 other bombers had visited upon Berlin was "a massive blow of retribution for all those who have fled from the sound of shots and blows on the stricken continent."

Responding to Stokes' parliamentary question, deputy prime minister Clement Atlee had said, "There is no indiscriminate bombing. As has been repeatedly stated in the House, the bombing is of those targets which are more effective from the military point of view." Atlee's statement, most historians agree, was not only dissembling, it was foolish. First, it set up the government for future criticism on its own terms. Second, despite Stokes' reference to "a growing volume of opinion" against the bombing, popular opposition was slight. The British public had lived through the Blitz and Coventry. Max Hastings, though critical of the bombing strategy, wrote, "It is most unlikely they would have opposed area bombing if they had been allowed to vote on it." He tells of one Royal Air Force officer who made morale-building visits to aircraft factories: When he told one audience that the flames of German cities burning could be seen 50 miles away, they "burst into cheers."

Murrow, meanwhile, had drawn a lesson of his own. What most governed Murrow's outlook, fellow newsman Eric Sevareid later noted, was that he "was a great moralist. He expected individuals, and his government, to live up to high moral standards." The typical Murrow broadcast contained a moral, often one that used the specific to illuminate the general.

In his broadcast, Murrow reported that as the bomber was returning to England, Dave, its navigator, announced when the craft left the airspace of German-occupied Europe for that of the English Channel. When Murrow heard that announcement, he said, his mind went back to a 1938 flight he had made to London from Prague. Seated ahead of him were two refugees, an older couple. When the pilot announced the airplane had left German territory, "the old man reached out and grasped his wife's hand." Murrow's comment: "The terrible symphony of light and flame" that *D for Dog* and 500 other bombers had performed upon Berlin was "a massive blow of retribution for all those who have fled from the sound of shots and blows on the stricken continent."

The judgment that bombing was retribution is one military historians sharply reject. "Harris was not much interested in retribution and neither am I," Robin Neillands says. "His aim was to shatter Germany from the Rhine to the Oder and weaken that nation's eagerness to fight." Richard Overy notes, "Most of the prevailing propaganda was very keen to argue that this was not in any sense retribution or revenge. Rather, it was based on solid assessment of the enemy's social and economic weakness, which is going to be attacked and undermined, leading to that enemy's surrender." Overy added that Murrow's view may reflect "the more popular sense that the Germans had done pretty nasty things and that they deserved everything they got."

Known today by the memorable phrase "orchestrated hell," Murrow's broadcast helped him win the coveted Peabody Award for radio journalism. Still, superiors at CBS had been aghast at the prospect of putting him in a bomber over Berlin. Murrow was their treasure—the world's first newsman as star—and the thought of his being shot down appalled them. Following the *D for Dog* broadcast, CBS news director Paul White sent Murrow a note. While he appreciated Murrow's motives in wanting to go, White said, "I hope you are cured. Please, please, please don't do it again."

Visiting London, network president William Paley confronted his chief European correspondent: "I tried to convince him that that he was a damn fool to go out on so many night bombing missions over Germany." Going once, Paley acknowledged, enabled Murrow to talk authentically on the subject, but "what do you have to gain to do it the second, third, fourth, or fifth time?" He would always say, 'Oh, I agree with you.' " Then, a few nights later, Murrow would head out on another mission.

Sevareid thought Murrow was afraid to admit he was afraid. During the Blitz, Murrow had refused to set foot in bomb shelters, telling a fellow correspondent, "Once you start going into shelters, you lose your nerve." Possibly, by 1943 Murrow simply felt dishonest—living the life of a much-toasted broadcaster in London while men younger than he were dying in a war he had worked to bring the Americans into.

When Tim Wright photographed the wingwalking team Beauty and the Beast at the Bealeton Flying Circus in northern Virginia in the spring of 2004, he had the jitters. "I can't recall any assignment that had me so tense," he says. Pilot Kirk Wicker and wingwalker Joanna Simpson perform a 20-minute routine—if you can call this type of work "routine"—in a Stearman, generally considered the ideal aircraft for wingwalking: Built as a trainer, it's known for its sturdiness and stability. "The photo flight was the first time they had flown that season, due to an unusually wet spring," Wright says; in his experience, such layoffs can sometimes lead to mishaps.

Wright was a passenger in another Stearman for the photo immediately below. For this "hang down" maneuver, Simpson wears a rock climbing harness with a ring attached to a safety rope on the wing. Nonetheless, "I was terrified that something would happen and Joanna would get hurt just so I could make a picture," Wright says.

In the photo below, the Stearman, with a 450-horsepower engine replacing the stock 220-hp model, is in a spin. The camera is mounted on the base of the vertical stabilizer, and Wicker has triggered the shutter from the cockpit. "The camera rotated slightly to the right to create the off-center composition," Wright confesses. "I goofed, but it looked pretty cool so I kept it." For the close-up of the hang down, opposite, "I attached the camera to the lower wing and just pointed it where I thought she would be," he says. Wicker again triggered the shutter from the cockpit. "I was never so glad to have a shoot finish," Wright adds. "I was a nervous wreck."

Lockheed's Lovely Airliner

Queen of the Skies: The Lockheed Constellation

by Claude G. Luisada. Ivy House, 2005. 404 pp., $39.95.

When it was introduced in the early 1940s, the Lockheed Constellation's speed and range redrew transcontinental and transoceanic air routes.

Countless variations on the aircraft's basic design served airlines and the military through the 1970s, and included the three Columbines that carried Dwight Eisenhower on his Army and presidential journeys.

"Connies," as they were fondly called, once flew over the author Claude Luisada's Chicago home and ferried him across Europe and north Africa—and one gets the impression they left their mark. Luisada, a member of the Civil Air Patrol, provides a reverent and encyclopedic account of the aircraft.

The book is organized chronologically, reaching a high point with the EC-121 Warning Stars, introduced in 1950. The Warning Stars were used as Airborne Early Warning and Control craft by the United States military, and production of these types of Connies would eventually account for 25 percent of Connies ever built.

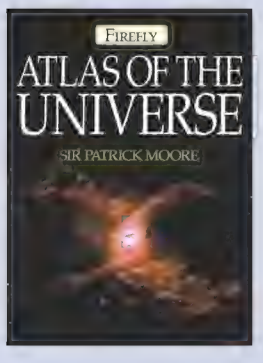
Once you've read the book and want to see a real, live Constellation in action, head to this year's AirVenture in Oshkosh, Wisconsin. Airline History Museum's *Star of America* Super Constellation will be flying in to make an appearance, and interior tours will be offered as well.
—Sam Goldberg is a Tacoma, Washington-based writer and former Air & Space/Smithsonian *associate editor.*

LOCKHEED MARTIN

President Eisenhower's VC-121C Super Constellation sits on the Lockheed delivery ramp in 1954, accompanied by other military transports and Airborne Early Warning aircraft, and commercial models awaiting their new owners.

WORTH NOTING

Atlas of the Universe



by Sir Patrick Moore. Firefly Books, 2005. 288 pp., $49.95.

Let's say you're cruising through the universe, letting your mind wander, when you realize you've let yourself go several million light years off course. What book would you want to pull out of your cosmic glove compartment? *Atlas of the Universe* would be a smart choice—there is hardly a speck of the known universe left without description.

The Space Tourist's Handbook

by Eric Anderson and Joshua Piven. Quirk Books, 2005. 192 pp., $15.95.

This slim little volume will fit in a space traveler's flightsuit pocket, and that's where Space Adventures president, Eric Anderson, wants you to carry it. His partnership with Josh Pivens (*The Worst-Case Scenario Survival Handbook*) gives the book a bit of a split personality. On one level, it's a spaceflight primer and a brochure to attract customers to the high-flying packages offered by Anderson's company. Yet a good portion of the material reminds us that private space travelers risk being blown up, seared by radiation, accelerated to the point of unconsciousness, and nauseated by orbital free fall. Welcome aboard!

To some, sunglasses are a fashion accessory…

But When Driving, These Sunglasses May Save Your Life!

Drivers Alert: ***Driving can expose you to more dangerous glare than any sunny summer day at the beach can…do you know how to protect yourself?***

An amazing breakthrough in optic technology by NASA resulting in Eagle Eyes® can be your answer. The sun rises and sets at peak travel periods, during the early morning and late afternoon rush hours. Many drivers find themselves temporarily blinded as they are driving directly into the glare of the sun. Deadly accidents are regularly caused by such blinding glare. Danger can come from reflected light off of another vehicle, from the pavement, or any other reflective surface. Early morning frost or dew can exacerbate this situation. Salted or snowy road conditions can make matters even worse. Yet, motorists struggle on despite being blinded by the sun's glare and cause countless accidents every year.

Beware of windshield glare!

This glare-induced "blindness" is especially prevalent in the early morning or late in the afternoon, and due to the extremely reflective qualities of other cars. Even your windshield can make matters worse since wax and oil buildup can increase reflected glare. This powerful glare of the sun is damaging to the various layers of the eye. Certain road conditions may raise the amount of harmful UV that you are exposed to by 85%.

NASA's researchers looked to nature for a solution.

Conventional sunglasses can in fact blur your vision by exposing your eye to harmful UV, blue light rays, and reflective glare. They can also darken useful vision-enhancing light. At NASA's Jet Propulsion Laboratory, scientists looked to nature for a solution by studying the eyes of eagles, known for their extreme visual acuity. The result of this breakthrough optical technology is Eagle Eyes®. NASA's researchers studied how eagles can simultaneously distinguish their prey from their surroundings with utmost precision, while protecting their eyes from the daily exposure of harmful high-energy sunlight. These studies led to this revolutionary protection for human eyesight.

Slip on a pair of Eagle Eyes® and everything instantly appears more vivid and sharp. You'll immediately notice that your eyes are more comfortable and relaxed and you'll feel no need to squint. The scientifically designed sunglasses are not just fashion accessories—they are necessary to protect your eyes from those harmful rays produced by the sun during peak driving times.

"As a board certified ophthalmologist, I recommend Eagle Eyes® to all my patients to protect and enhance their vision!"

—Dr. Lyda D. Tymiak

Patented triple filtering lens system.

With a patented triple filtering system, Eagle Eyes® will reduce the blinding glare you may encounter while driving or enjoying outside activities. The lenses will block the UV light while enhancing the colors of your surrounding environment. Eagle Eyes® provides 100% eye protection from harmful blue, violet and ultraviolet light rays. You can experience enhanced visual acuity, even at great distances in most weather conditions. Even on cloudy days, the advanced lens technology improves your visual acuity.

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Ninety-eight percent of people wearing Eagle Eyes® love them. It's the highest customer satisfaction rate that we have seen in our 20 years history. We are so anxious for you to try the Eagle Eyes® breakthrough technology that when you call for the Eagle Eyes® Extremes™ we will give you the Explorers™ FREE!

That's two ways to protect your eyes and prevent blinding glare for less than the price of one pair of traditional sunglasses. You'll also receive free one hard leatherette case and one soft cloth pouch so you can carry and protect your Eagle Eyes® in style. Plus, if you are not thrilled with the Eagle Eyes® technology, just send them back for a full refund of the purchase price. You should always have a pair of sunglasses available when you drive, so put Eagle Eyes® in all of your cars and start seeing the world without the dangerous squinting and with more clarity than you've ever imagined.

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The well-organized handbook takes a prospective traveler briefly but engagingly through spaceflight training, the daily routine aboard a space station, and the physical stresses of reentry. The scenario getting the most ink is Space Adventures' current orbital offering, a Russian Soyuz jaunt to the ISS, an experience already enjoyed by Dennis Tito, Mark Shuttleworth, and Greg Olsen—millionaires all. Although few tourists can ante up the $20 million for that jaunt, cheaper suborbital travel is nearly set to lift off.

The book has a few shortcomings: a hard-to-read typeface, nearly invisible neon-green-on-white captioning, and enough exaggerations to make the technically savvy squirm.

My experiences in orbit far exceeded my expectations, even after I heard countless stories from my shuttle colleagues. Prospective space tourists will similarly find that this compact guide has barely scratched the surface of what awaits them in free fall, a hundred miles above our stunning planet.

—Retired astronaut Tom Jones is the author of Sky Walking: An Astronaut's Memoir.

The Blue Angels: A Fly-By History

by Nicholas A. Veronico. Zenith Press, 2005. 176pp. $34.95.

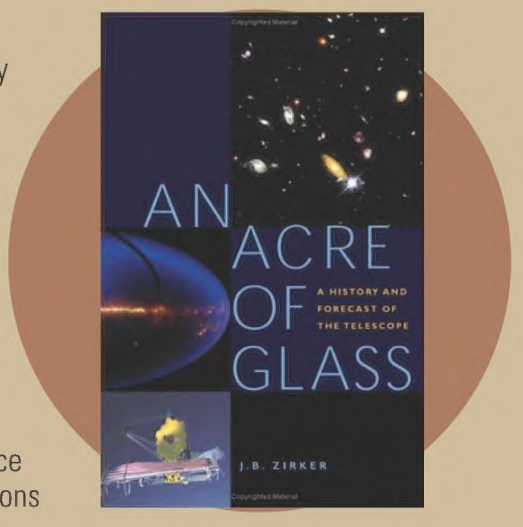
At its first public performance on June 15, 1946, the Navy Flight Exhibition Team flew three blue and gold Grumman F6F-5 Hellcats, performing loops, rolls, inverted passes, and elaborate aerobatics in precision formation as low as 50 feet off the ground. As if that weren't enough to shake up the crowd at the Southeastern Air Show and Exhibition in Jacksonville, Florida, the team then came under attack as an airplane made to look like a Japanese Zero came in shooting from behind the stands. After a simulated air battle, the enemy plane began streaming smoke and, to all appearances, ejected a wounded pilot.

"It was kind of hocus-pocus," recalls Lieutenant Commander Roy M. "Butch" Voris in the first of many interviews with author Nicholas A. Veronico. "Everybody thought he was really shot down."

Veronico's oral history of the team, now known as the Blue Angels, relies

An Acre of Glass: A History and Forecast of the Telescope

by J.B. Zirker. Johns Hopkins University Press, 2005. 360 pp., $30.00



In 2009, astronomers will mark the 400th anniversary of the invention of the telescope. Anticipating that celebration, retired observatory director Jack Zirker "telescopes" four centuries of innovation into just over 300 pages.

Zirker takes the reader from Galileo's primitive yet revolutionary spyglass to football-field-sized reflectors now on the drawing boards in the United States and abroad. Along with historical details and engineering advances, Zirker chronicles scientific discoveries that individual telescopes made possible.

Until recently, the greatest surprise to a novice reading a book on telescopes was that despite tons of fine glass and precision heavy machinery, the performance of a telescope ultimately depends on a microscopically thin metallic film (usually aluminum, but sometimes silver) on the surface of a big mirror. Light never touches the glass itself, but reflects off the coating. However, as Zirker stresses, another technology is now paramount: Today's biggest, most advanced telescopes depend on electro-optical systems dubbed "adaptive optics" and "laser guide stars" to compensate for turbulence in the air, which would otherwise severely degrade their performance. Hundreds of pistons and levers push and pull on the backs of a mirror, hundreds of times per second, to make up for what air currents just do naturally. What would old Galileo say?

—Stephen P. Maran is the author of Astronomy for Dummies.

heavily on such anecdotes, particularly from Voris, the officer charged with establishing and training the first team. Naval flight enthusiasts will also find plenty to cheer about in Veronico's obsessively detailed chronology and photographs of the various aircraft used over the team's history.

The Navy's original objectives for the flight exhibitions were to motivate Navy recruitment and keep Naval aviation in the spotlight before military appropriations for aircraft carriers dried up during peacetime.

For Voris, however, it was personal. Determined to best the Army Air Corps and claim Naval air superiority, he designed spectacular shows full of risky maneuvers.

Voris selected and mentored his next two successors, then took command again in 1952, and Veronico credits his "Get it up, get it on, get it down" motto with influencing the entire history of the squadron. Voris anticipated the short-attention span demands of Generation Y way back in the heyday of the Greatest Generation, and Veronico's narrative illustrates how Voris' brash exhibition rules—fast, tight, no repeated maneuvers, 17 minutes start-to-finish—have remained benchmarks of the Blue Angels' demonstrations.

—Colin Bane is a Washington, D.C.-based writer.

Air & Space/Smithsonian magazine is now available on audio tape for members who cannot read standard print due to disability. For the basic membership fee, you will receive a print copy of the magazine plus the audio version. If you or someone you know has been struggling with the standard print version because of vision loss or other disabilities, contact the Smithsonian Accessibility Program at 1-888-783-0001 and receive your next issue of Air & Space on tape.

CALENDAR

April 1

Riverside Airport Open House & Airshow. More than 200 acres of airplanes and helicopters on static display, plus flight demonstrations and a classic car show. Aerobatic performances by Sean D. Tucker and Ed Hamill. Riverside, CA, (951) 351-6113,

U.S. Air Power Over Vietnam Seminar. The event will conclude with the flight demonstration of a Vietnam War-era military aircraft. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org.*

April 4–10

Sun 'n' Fun Fly-In. First civilian airshow performance by the U.S. Air Force's F-22A Raptor supercruise fighter. Lakeland Linder Regional Airport, FL, (863) 644-2431, *www.sun-n-fun.org.*

May 6

World War I Aviation Seminar. The event will conclude with the flight demonstration of a Planes of Fame aircraft. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org.*

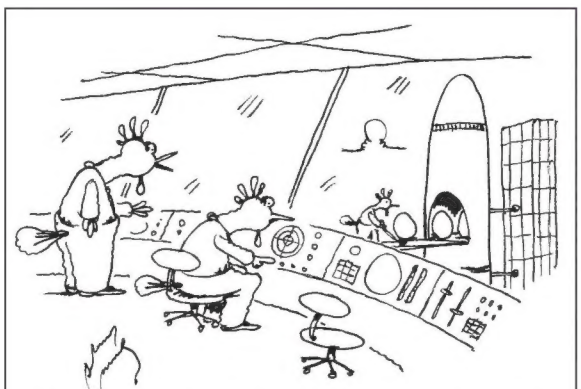
May 11–14

EAA Southwest Regional Fly-In. Hondo Municipal Airport, TX, (830) 889-8802, *www.swrfi.org.*

May 27 & 28

Salute to Veterans Airshow. Columbia Missouri Regional Airport, MO, (573) 443-2651, *www.salute.org.*

Organizations wishing to have events published in Calendar should fax press releases to (202) 275-1886; e-mail them to editors@si.edu*; or mail them to Calendar,* Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*



"It's risky, but it's the only way we'll make it all the way to Mars."

CREDITS

50 Feet, 600 Knots. Drury Wood was a test pilot who flew in the decades after World War II, when new models of airplanes came out as frequently as new models of cars. He also test-flew the Dornier Do-31, the only vertical-takeoff-and-landing jet transport ever to fly.

Blowing Off Steam. Stephen Joiner writes about aviation from Los Angeles, where he is not scanning the sky for the return of steam-powered airplanes.

Son of Apollo. Tony Reichhardt is a consulting editor at *Air & Space/Smithsonian.*

Paul DiMare has been an aviation and space illustrator for 28 years, and counts 20 major magazine covers among his commissioned works.

Le Airshow. Bettina H. Chavanne is a French girl who grew up listening to stories of "*les frères* Wright." She is an associate editor at *Air & Space.*

Jump in a Lake. Dan Ford flies a Piper Cub with wheels.

Gilles Auliard loves nothing more than hanging out of airplanes to take pictures. After crisscrossing the Old Continent, he came to the United States to chase one-of-a-kind flying machines.

Torture Chamber. Ed Regis, the author of six science books, is working on a new book entitled *What Is Life?*

How Things Work: Shuttle Tiles. Damond Benningfield, a freelance aviation and space writer in Austin, Texas, writes and produces the nationally syndicated radio series "Star Date."

Think Small. Patricia Trenner is a tiny senior editor at *Air & Space.*

Shuttle Stop. Read more from *Sky Walking: An Astronaut's Memoir* at Tom Jones' Web site, *www.astronauttomjones.com.*

Restoration: Barnstorming the Beltway. Ken Scott is a 54-year-old ex-potter who learned to fly in the early 1980s; since then he has spent much of his time building airplanes.

'Orchestrated Hell.' Mark Bernstein writes on American history. With Alex Lubertozzi, he is co-author of *World War II on the Air,* an account of Edward R. Murrow and the CBS correspondents in the European theater.

FORECAST

In the Wings. . .

Lunar Grit
Moon dust is more than an irritant; it's a foe that mission planners must defeat.

Finding Glenn Curtiss
Wander around Hammondsport, New York, and you'd never know that an aviation legend had lived and flown here.

Inflated Ambitions
NASA researchers look for a new way to explore space: interplanetary ballooning.

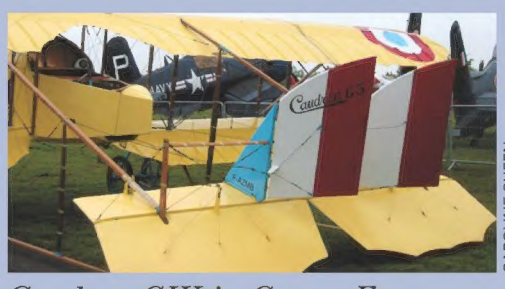
The Flying in Flyboys
In a world where Hollywood special effects artists can make horses dance and houses spin, is there room for real airplanes in this forthcoming World War I film?

JOHN DIBBS / THE PLANE PICTURE COMPANY

Filming Flyboys*: a Fokker DR III.*

ON THE WEB SITE

www.airspacemag.com



CAROLINE SHEEN

Caudron GIII in Cerny, France.

Want a close look at a Caudron biplane ("Le Airshow," p. 28) but can't afford a ticket to France? A photographic tour of a vintage Caudron, on display at the National Air and Space Museum, is available online. Views of the twin Le Rhône engines, machine gun, and seats give visitors a feel for what it was like to fly these wood-and-fabric airplanes into combat.

Images of other rare airplanes can also be seen on the Web, including steam-powered craft (Oldies & Oddities, p. 18) and additional images of the *Little Gee Bee* restoration, described on p. 62.

Heavy Honor for Light Jets

Someday soon, especially if the Eclipse Aviation Corporation has its way, people will be commuting to work in their Eclipse 500 very light jets, flying in and out of any one of the thousands of small airports nationwide.

In honor of its commitment to that vision, Eclipse has been awarded the 2005 Robert J. Collier Trophy for the year's "greatest achievement in aeronautics or astronautics in America." The 95-year-old trophy, one of aviation's most prestigious awards, will be presented to the company "for leadership, innovation, and the advancement of general aviation" in the production of very light jets, specifically, the Eclipse 500.

COURTESY ECLIPSE AVIATION

Rush-hour traffic? Possibly. Especially if the popularity of very light jets—like these Eclipse 500s—continues to grow.

Led by Eclipse's founder, president, and CEO Vern Raburn, Eclipse is applying technology to drive down cost, increase performance, improve safety, and spur a new type of air travel.

Perhaps the company's greatest contribution is making jet technology available to a larger segment of the population. With an acquisition cost one-third that of today's small jets and the lowest operating cost per mile of any jet, the Eclipse 500 provides the lowest jet costs in aviation history. As a result, almost 2,400 Eclipse 500s are on order.

Raburn has said that his company's vision is to provide what it considers a "missing link" in air transportation today. Most travelers who want the speed that jet engines afford have two choices: line up with hundreds of other travelers at airport security gates or pay a premium for corporate jet travel. Eclipse's missing link is the opportunity for a private individual to own and fly a jet aircraft.

Years ago, science fiction writers envisioned the 21st century as a time when people would be traveling in personal jets as easily as they do today in cars. Eclipse hopes that the launch of its very light aircraft, priced at about $1.4 million, will move the world of transportation closer to that future.

The Eclipse 500 is built to seat a maximum of six people and be flown by a single pilot. It is powered by two Pratt & Whitney Canada PW610F engines that provide 900 pounds of thrust each. The aircraft is only 33.1 feet long, with a wing span of 37.4 feet. It stands 11 feet tall, and can cruise at about 430 miles per hour. Loaded with three passengers and one pilot, it has a range of approximately 1,280 nautical miles.

Eclipse joins an illustrious group of past Collier Trophy winners, including Orville Wright, Howard Hughes, Chuck Yeager, the crew of Apollo 11, and SpaceShipOne. The award has been administered by the National Aeronautic Association since 1911.

LOGBOOK

Freefall University

Since 1957, college students from all over the United States have gathered annually to compete against their peers in the longest running skydiving competition on record, the United States Parachute Association's National Collegiate Parachuting Championships.

At this year's competition, held in Lake Wales, Florida, about 100 students competed in events including accuracy landing, freefall formations, and freefall aerobatics, called freeflying.

The competition is divided into novice, intermediate, and master classes. While formation skydiving recognizes winners of the two- and four-way events, the three remaining events—sport accuracy, classic accuracy, and freefall style—award medals in each of the three classes. Judges then combine each competitor's rank in classic accuracy with his best freefall event to determine the overall score. This year's winner—West Point cadet Greg Hastings—was crowned the National Collegiate Champion, and earned a handsome medal and the Istel Scholarship Award.

Fifty years ago, Jacques Andre Istel came to America to start his unique skydiving school just outside of Boston, Massachusetts. In 1969, his family arranged to have the National Aeronautic Association manage a trust fund in his honor—the Andre Istel National Collegiate Parachuting League Scholarship Award Fund. Since the fund was designated for educational purposes, if the winner is a student at a military academy (and therefore not paying tuition), he or she passes the monetary award on to the second-place winner. Hastings bequeathed his scholarship money to students from the University of Georgia skydiving team.

—Larry Bagley

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa.aero *or call (703) 527-0226.*